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AIR RECONNAISSANCE AND ARCHÆOLOGICAL DISCOVERY

AIR photography is now recognized as a means of archæological discovery which yields results unobtainable by any other method. This special applicability is due to the power of an aerial camera to record the earth's surface comprehensively, including not only all major features shown on large-scale maps, but also many minor and often transient details that maps do not present. The present form of any given landscape is the result of a long and complicated development by Nature and man, and each feature in it reflects some part of that process. That is why air photography has come to be extensively used for geological survey, since the detailed picture of physical features which it affords often supplies information about geological structure. Artificial elements in a landscape, on the other hand, include not only the present cultural pattern but also remains of every period since man first left his mark upon the surface. The most obvious of these remains still exist above ground, and embrace a wide variety, from structures in earth or stone, belonging to prehistoric and Roman times, to medieval villages, castles and abbeys, all plain to see and readily studied on the ground. Yet they also include very many structures, now covered by arable land, which have been so reduced or masked by agriculture that they are difficult to plan, and often scarcely perceptible to an observer walking over them. Such sites may be effectively photographed in morning or evening sunlight when low banks and ditches cast the long shadows that emphasize minor features in faint relief.

In the right conditions, however, air photography has much to reveal of buried features of which there are no surface traces whatever. Land which has long been under plough may cover completely obliterated ancient sites. An air observer may see them outlined or patterned by differences in the soil, or in the colour and growth of vegetation above them. Such soil-marks or crop-marks often give an extraordinarily detailed picture of buried features. In fact, photographs taken under good conditions may not only disclose a new site, but also, by showing its detailed plan, indicate clearly its character and period.

These principles, simply enough stated, cover a wide range of conditions, for in practice the revelation of a given site depends upon the soil, the vegetation and its state of growth, and the weather, both at the time of photography and during the preceding season. In general, long-rooted cereals, viewed in late spring and early summer, give the most sensitive renderings. Root crops, if they respond at all, give only a blurred image of major disturbances in the soil. Grass is seldom responsive, except in drought. Thus in any given year only a certain proportion of agricultural land is likely to yield results; but if a site is observed over a period of years it will sooner or later be in the right state for observation, as each year brings different crops to each field in rotation. Nevertheless, the limitations described are heavily outbalanced by the vast quantity of material available. The main

problem to-day is not the finding of new sites, but rather how best to record the information in the limited time available for observation, for each group of subjects has its season. Earthworks in open country are best photographed in winter and spring, when least obscured by vegetation, and when the sun is low. Soil-marks go with the fresh ploughing in autumn and early spring. Crop-marks, by far the most productive source of new discoveries, demand observation in spring and early summer, while crops are still green.

Present agricultural conditions in Great Britain offer exceptional opportunities for this work and create a new urgency. Land development is now planned on an increasing scale; exploitation of land not normally brought under the plough, the so-called marginal land, inevitably affects many earthworks, so that either the last chance is now passing of observing them in unploughed state, or new opportunities are coming for viewing the same works as crop-marks. This information may be recorded in two ways. There are high-altitude vertical photographs taken for another purpose, such as the National Air Survey. But these photographs are secured at any convenient time of the year, and therefore crop- and soil-marks only occur in them by chance. Their greatest value to archæology lies in their record of earthworks in grass or moorland which have hitherto escaped notice on the ground. Scrutiny of all such photographs, especially of unploughed land, is thus well worth undertaking; and their relatively small scale is partly compensated by the fact that they overlap and may be viewed stereoscopically. But it is the second method of photography that is the better. This is low-altitude reconnaissance specially undertaken for the purpose and planned in relation to particular needs at the appropriate time for observation.

Some of the results of the application of air photography, and particularly the planned reconnaissance, have become common knowledge. The Stonehenge Avenue, the prehistoric religious site at Dorchester, in Oxfordshire, Celtic fields on Salisbury Plain, and Roman town-plans at Caistor-by-Norwich or at St. Albans, are outstanding examples in Great Britain. Special reconnaissance flights undertaken each summer since the Second World War have yielded a large quantity of material, illustrating many periods of prehistory and history. In the Neolithic age, a number of new examples of the *cursus*, a very long and narrow rectangular ditched enclosure, has been found, extending the known area of distribution of these monuments. Photographs of Neolithic hill-top camps disclose fresh details of these sites. Discoveries of new religious monuments have been made at Birrens in Dumfriesshire, at Coupland (Northumberland) and at Elston (Notts).

A large number of Iron-Age hill-forts has been photographed from the air. Not only have new forts been discovered in this way, but also knowledge of sites already known has been greatly increased, since photographs show that the forts have often undergone an unexpectedly long and complicated structural development. Native villages and prehistoric agriculture are other subjects illuminated by air photography. Many ancient earthworks are difficult to date in isolation; but an air photograph will often show them in visible relationship to known remains, thus either establishing their relative age or showing where planned excavation can attack the question.

Air photography has greatly increased our knowledge of both the military and civil districts of Roman Britain. In the north a large number of new forts, signal-stations and temporary camps has been found along already known lines of advance, and elsewhere, in districts not previously known to have been penetrated, as, for example, western Dumfriesshire and Galloway. In the south, the discovery of military sites on Watling Street offers an unexpected chance of learning about the early history of the Roman conquest. Important discoveries have been made in the civilian sphere. One hundred acres of the plan of the tribal capital of Wroxeter in Shropshire have been recorded on air photographs that reveal not only the street-plan but also public buildings, shops and large town-houses, and even mosaic or concrete floors. In the smaller towns significant new features have been seen and photographed at Catterick, Kenchester, Stretton Bridge, Irchester and Mildenhall (Wiltshire). Country houses, Romano-British villages and the associated fields are other subjects upon which air photography has thrown much light.

Earthworks of the Dark Ages and of the medieval period call for detailed examination from the air. Existing remains are often difficult to recognize and to interpret; but it should be possible to date them in relation to other features. Traces of abandoned medieval villages are common in many parts of Britain. A comprehensive air survey showing these settlements, their drove-roads and related agriculture, would provide invaluable material for historical and economic studies.

The early history and prehistory of Britain can thus be studied from the air more effectively than in any other way yet available. It is of the greatest importance and urgency to record this rich historical material now. The surface of Britain is to-day undergoing change at a greater rate than ever before. New building, open-cast mining, afforestation and more intensive agriculture are covering or obliterating large areas of countryside and effectively destroying any archæological sites that lie there. While land utilization can take account of visible remains, planning based upon visible remains cannot allow for sites which leave no trace on the surface. Yet it is these sites that often contain the most important material for history.

A planned programme of air photography over the next few years is the only possible way of securing the necessary record. Moreover, the time available is limited. In many cases it will be either now or never, for the opportunity once lost will never return.

It must be emphasized that the very richness of the British Isles in crowded and superimposed cultures makes them an area of unique importance for regional and historical studies, a heritage not merely of national value but also one in which all the civilized world may claim a share.

EINSTEIN AND RELATIVITY

The Meaning of Relativity

By Albert Einstein. Fourth edition. Pp. v+146. (London : Methuen and Co., Ltd., 1950.) 7*s*. 6*d*. net.

THIS book is a new (the fourth) edition of Einstein's Stafford Little Lectures, delivered in May 1921 at Princeton University, supplemented by two appendixes, one on the "Cosmologic Problem", the other on the "Generalised Theory of Gravitation". It is the latter appendix which will attract the attention of physicists and mathematicians, because it contains the first complete account of Einstein's new attempt to establish by *a priori* reasoning the fundamental law of physics. But this appendix cannot be properly understood without a careful study of the whole book, and whatever the reader may think of the somewhat hazy view from the summit, he will enjoy the path which leads up to it. In fact, Einstein's presentation of the special and the general relativity is so simple, clear and convincing, that it can not only be recommended to students as a first introduction, but will also provide material for thought to scholars who are interested in the logical and empirical basis of the theory. The last chapter of the book ends with a consideration of Mach's ideas about the origin of inertia in connexion with the question of whether space is finite and closed, or infinite and open. This cosmologic problem is taken up in a wider frame in Appendix 1, which gives an account of Friedman's original theory. Later contributions to the theory of the expanding universe, the work of Lemaître, Robertson, Eddington, Milne and others, are not mentioned.

Appendix 2 is a confession of Einstein's deepest convictions about the structure of the material world, which have alienated him from the general trend of contemporary physics. He starts with the remark that the fundamental law of general relativity, which equates the contracted curvature tensor of space–time to the energy tensor of matter, is unsatisfactory because of its dualistic character, and he proclaims his aim to establish a unitary theory, in which there exists only one field, subject to a law of the form : some generalization of the curvature tensor is zero. No separate energy tensor of matter ought to be introduced ; it should later appear automatically if the new equations of the unitary field are split in two parts, one representing the action of inertia and gravitation, the other the rest of physical phenomena.

The natural way of obtaining the postulated generalization is, according to Einstein, the introduction of a metric tensor $g_{\mu\nu}$ which is not symmetrical. It can, of course, be split into a symmetric and skew-symmetric part, and it might be expected that the latter has something to do with the electromagnetic field. The objection may be raised that these asymmetric $g_{\mu\nu}$ are not an irreducible set of quantities, since each of the two parts is by itself a tensor. Einstein rejects this group-theoretical point of view as not being the only relevant one, and shows that a coherent tensor calculus based on the non-symmetrical metric tensor can be developed and leads to reasonable results. Thus Einstein arrives at field equations of the formal type required. The main difficulty is the proof of the compatibility of the equations. The question now arises whether Einstein's equations fulfil his expectations of providing the foundations of a rational theory of matter. There is, however, no answer ; the book ends with the sentence that these equations "form a system, of utmost simplicity, compatible in the usual sense". No solution and no discussion of the physical content are given.

What we have before us might therefore be better described as a programme than a theory. Einstein obviously hopes that his equations may have solutions which lead to the localization of energy, usually described as quanta, and to the laws of distribution of these quanta in agreement with wave mechanics.

The motive behind this programme is Einstein's well-known philosophical attitude. He believes that quantum mechanics is unsatisfactory, because it describes, not the behaviour of an objective world, but rather the reaction of the physical objects to the experimental conditions. Therefore he tries to find a theory of the classical type of such refined structure that it contains the essential features of atomistics and quantum theory as consequences. There are at present few physicists who share this view. However, most of them will agree with Einstein that the final synthesis of relativity and quantum theory has yet to be made.

MAX BORN

TOWN PLANNING

Cities in Evolution

By Patrick Geddes. Edited by the Outlook Tower Association, Edinburgh, and the Association for Planning and Regional Construction, London. New and revised edition. Pp. xxxi + 241. (London : Williams and Norgate, Ltd., 1949.) 18*s*. net.

"CITIES in Evolution" was first published in 1915, just after the total loss of Geddes's first Town Planning Exhibition *en route* to India, and, apart from his earlier comprehensive study of the town planning of Dunfermline, undertaken at the request of Andrew Carnegie and published in 1903 under the title "City Development", it is the only book on civics and urban development that Geddes wrote. The book was intended to help the citizen to understand urban processes and to secure his active co-operation in urban development. Geddes's immediate influence was mainly direct and personal ; but probably no one has done more to inspire the planning of cities and of regions to-day, and the reappearance of a volume which has so long been out of print should enable a new generation to judge for themselves how much the best elements in such planning owe to the thought of Geddes.

The present volume, however, is not simply a reprint of the original edition. Four chapters in that edition, those dealing with the homes of the people, the housing movement, a town-planning tour in Germany, and recent progress in housing and town planning, and all but two paragraphs of a chapter on German organisation have been omitted as being no longer of interest. Most of the deletions, which have been agreed between Dr. A. Geddes, Mr. Phipps Turnbull and Sir George Pepler, are fully justified, and any omissions are more than balanced by the inclusion of fresh material which gives the modern reader a clearer idea of the range of Geddes's social philosophy. The introduction includes an extract, dealing with the Valley Section, from a lecture given by Geddes at the New School of Social Research in New York City in 1923, which illustrates his use of the historical and geographical survey of occupations

as an approach to regional development and city planning. Illustrations selected from Geddes's second Town Planning Exhibition are accompanied by a text drawn from his catalogue to the first Exhibition. These illustrations replace the original illustrations for the book. Next, in an appendix, his diagram of the Notation of Life is reproduced with an explanatory note on it by Geddes himself, and an appreciation of the importance of the contribution of his graphic presentation of interrelated phenomena to the growth of a synthetic or unitary form of thought. A chapter from Geddes's "Sunday Talks with my Children", and a description with extracts from his final Dundee lecture, "A Botanist Looks at the World", completes the new material.

The outstanding impression on reading or re-reading this representative sample of Geddes's thought on cities and on civilization is the relevance of much of his views to post-war planning and reconstruction to-day; and the remarkable extent to which he has anticipated, where he may not have inspired, comparatively recent developments or trends of thought. Geddes's approach to his subject was coloured by his training as a biologist, and his general habit of mind also made him an ecologist long before ecology was regarded as a special discipline. In this book he is arguing on the lines that to-day have led to the establishment of the Nature Conservancy or, in a wider field, inspired the holding last year at Lake Success of the United Nations Scientific Conference on the Conservation and Utilization of Resources, though he has tended to overestimate the direct effect of technical advances on social life, and to underestimate the extent to which surviving social institutions and customs can subvert both science and technology.

That, of course, only justifies Geddes's concentration on education rather than politics as the primary task. Mr. Lewis Mumford, who freely acknowledges his own indebtedness to Geddes, has, indeed, characterized Geddes's most important contribution to the planning of cities, not as that of a bold innovator in urban planning, but as an ecologist, as the patient investigator of historical origins and social traditions and of dynamic biological and social interrelationships. He had grasped forty years ago the latent idea of the neighbourhood unit and the essential importance not only of the individual but also of the small group in which the free expression of personality, of interest and of service is possible. His outlook and method contribute to the planning of to-day precisely those elements that the administrator and bureaucrat are prone to disregard or omit. Each valid scheme, Geddes insists, should and must embody the full utilization of local and regional conditions, and be the expression of local and regional personality.

"Cities in Evolution" is a book to be read and studied not only by all responsible for town and country planning or concerned with any aspect of social or physical planning, but also by those who are concerned with the whole problem of local government and the maintenance or emergence of conditions in which an effective democracy is possible. Geddes makes plain in this book the immense complexity of the whole subject of town or city planning —the necessity for time and patience and care of detail, the meticulous regard which must be paid to the interrelation of past and future. But, most of all, he emphasizes the importance of the human scale and the human purpose above all merely mechanical requirements, and of a readiness to leave an essential part of the process to the ultimate consumers or citizens who are most intimately concerned with it. For that insistence upon sympathy and human understanding, upon—to use the phrase that he and Branford coined—the resorption of government, the reappearance of this exposition of Geddes's philosophy of planning is to be welcomed. The book should be widely read and appreciated, and may well give a fresh impetus to creative thought in this field, as well as check some of the excesses which have marred some post-war developments. R. BRIGHTMAN

PSYCHOLOGICAL ILLNESS

Textbook of Abnormal Psychology

By Prof. Carney Landis and M. Marjorie Bolles. Revised edition. Pp. xi+634. (New York: The Macmillan Company; London: Macmillan and Co., Ltd., 1950.) 37*s.* 6*d.* net.

THIS is a revised version of the authors' previous text-book, and they say with truth that it is significant that their book has become outdated within five years. There used to be a complaint against text-books that they were copied from each other and contained no recent work. It was easy to discover this, since poor documentation made it impossible to find the origin of the material presented. No one can make a similar complaint against this excellent text-book. At the end of each chapter there is a list of ten to fifteen references, mainly from journals, and in the front are acknowledgments of direct quotations, figures and tables used in the compilation.

The authors attempt to give a fair presentation of the known facts of psychological illness, and although case-histories are given they are not used, as is so often the case, to pad out the work, but are really illustrative of the diseases described.

The book is divided into five sections. The first is mainly introductory but includes a chapter on psychopathology. This is eclectic and includes the work of Kretschmer, Kraepelin, Meyer and Freud. The second section is devoted to descriptions of various mental diseases with illustrative cases. The third is explanatory, with chapters on heredity, culture and environment, development and so on. Section 4 is devoted to psychopathology and is influenced by the old-fashioned functional psychology —it gives disorders of sensation, impairment of intellect, diseases of volition and so on, as if these were separate entities. The authors very reasonably excuse this by pointing out that they do so because "(*a*) it brings the material in line with normal psychology, and (*b*) most of the psychological experiments have been conducted and reported in these terms. Until such time as a more adequate system of classification of psychological phenomena is formulated, and until the facts now arranged in the older classifications are translated into some new system, the conventional system, admittedly unsatisfactory, is still preferable." The final section is concerned with psychodiagnosis, the law and treatment.

In general, the illustrations of diseases, most of which are drawings, are good, but one or two fall from the high standard; for example, the sketch of a cretin on p. 272 does not show the characteristics of the disease sufficiently to help in diagnosis to those unfamiliar with the condition.

The descriptions are good, and the book avoids the excessive Americanisms which are so irritating and puzzling to those who have not lived in the United States. The care with which the book has been compiled makes it a pleasure to look up a fact, and the reader can be sure of finding the latest information on almost any psychiatric subject.

CLIFFORD ALLEN

ESSENTIAL OILS OF THE CITRUS AND MINT FAMILIES

The Essential Oils

By Dr. Ernest Guenther. Vol. 3: Individual Essential Oils of the Plant Families *Rutaceae* and *Labiatae*. Pp. xvi + 777. (New York: D. Van Nostrand Co., Inc.; London: Macmillan and Co., Ltd., 1949.) 75*s*. net.

IN this third volume Dr. Ernest Guenther begins to speak of trees, though, inverting Solomon's order, he has placed the hyssop near the beginning of his discourse and reserved the cedar, no doubt, for later treatment. The order chosen is, in fact, that of commercial importance, giving priority accordingly to the two botanical families which include peppermint, lavender and the citrus group.

The alternative of classification on a taxonomic botanical basis may well have appeared a tempting one. A phylogeny of plants in terms of their chemical components, elegantly illustrating the achievements of the morphologist and resolving his dilemmas, seems one of the most attractive prospects which chemistry may still have to offer. Bold spirits, quoted in Dr. Guenther's first volume, have already "distinguished species indistinguishable by ordinary morphological techniques, on the basis of the production of oils of different chemical composition". A more modest example from the present volume, namely, Fujita's chemical demonstration of the interrelations of fifteen species of the tangled labiate genus *Orthodon*, may be mentioned as noteworthy, inasmuch as Fujita's work is not otherwise easily accessible.

On the other side, the present volume cites cases of distinctly different oils being produced in identical conditions by trees showing, at most, the differences of horticultural strains of one and the same variety. Throughout the book, moreover, there is ample evidence of the dependence of essential-oil composition on the phase of maturity of the plant, and on geographical, ecological and less tangible factors, some of which are further detailed below. If a taxonomy by essential-oil content is ever to be constructed, Dr. Guenther's work will provide a rich quarry of the necessary material, and the "table or key showing the classification of the oils according to a modern botanical system", envisaged as an item in his final volume, must be awaited with interest. For the present, however, the choice of a perspective which relegates this mistier outline to the background seems well advised.

These volumes may therefore be taken as primarily for the benefit of essential-oil producers and consumers and the analysts who advise them. There is much wisdom in the warning that "the two points of view—one aimed at finding out what is wrong with the oil, and the other at trying to define the facts relative to pure oils—not infrequently lead to different conclusions". In effect, it is to the convenience of the consumer to define the authenticity of any oil by analytical criteria as sharp and narrow as possible; but with this ambition the enterprise of the producer, complementing that of Nature, is continually in conflict.

Within the past decade, large-scale essential-oil industries have been developed in areas more or less remote from the original homes of the plants concerned. The Argentine is now a large producer of peppermint oil, Brazil of the menthol-rich oil of corn-mint. In the U.S.S.R., though information from there is found confused and contradictory, at least the foundations of a large lavender industry appear to have been laid (it is of interest to note that, in comparing the oil yields of more than nine hundred strains, a count of the oil-sacs on only five sepals is said to give a satisfactory assessment of the productivity of any one strain). Change of habitat on this scale must always be a probable source of change in the characters of the relevant oil. Of this there is a striking example in the mandarin and tangerine oranges, which for oil-producing purposes in the eastern hemisphere have usually been considered synonymous, but which in Brazil yield oils of decidedly different character, while in North America the oil is wholly of the type 'tangerine', with optical rotation much higher than in any mandarin oil. (The American idiom which distinguishes these oranges with flexible and smoothly peeling skin as the 'kid-glove' type is one at which it is surely proper to pause and admire.)

To variations of this kind must now be added those which are beginning to be produced by artificial genetic modifications, for example, in the tetraploid peppermints recently obtained at Purdue University by colchicine treatment, and the artificial hybrids, said to contain oil-constituents not present in the parents, bred by Russian workers from species of *Ocimum*. Notice should also be taken of variations in oil character correlating with changes in extraction technique, especially in the citrus fruits. A much increased demand for citrus juices fitted for beverage purposes, coinciding over recent years with a declining importance of citrus pulps, compared with the fermentation-vat, as a source of citric acid, may involve changes in processing quite sufficient to modify the analytical character of the oil, and to raise a doubt of its authenticity if judged by any too dogmatic criterion. Through these pitfalls for the authenticating analyst, Dr. Guenther must prove an invaluable guide. In at least one matter of nomenclature, also, he is consistent in a usage which might avoid no little confusion if generally adopted, namely, the treatment of the descriptions "neroli" and "petit-grain" purely as adjectives, respectively equivalent to "distilled from flowers" and "distilled from shoots" and meaningless in themselves until the name of the tree concerned is added.

In its detailed structure, the book is a series of monographs on all the recognized varieties of the oils within its scope, covering history, production technique and statistics, analytical characters and as much detail of chemical composition as is available. With the examples of the first two volumes before us (see *Nature*, **163**, 663; 1949 and **164**, 895; 1949) it is scarcely necessary to say that it is excellently produced and indexed; though it may be observed that, in both index and text, hesperetin is misprinted in a form, hesperitin, which could confuse it with hesperidin.

E. G. KELLETT

The Dianthus

A Flower Monograph. By Will Ingwersen. Pp. 128+29 plates. (London and Glasgow: Wm. Collins, Sons and Co., Ltd., 1949.) 10*s.* 6*d.* net.

THE genus *Dianthus* is at once a group of plants that appeals equally to the horticulturist, to the botanist and to all those who love plants for their colour, scent and beauty. It is a genus to which the breeder has paid considerable attention, and, if the outcome of his efforts has not infrequently been to produce types that are both ill-proportioned and scentless, he has also produced others that are real acquisitions to the rock garden and the border, such as 'Charles Musgrave'. In the pages of this book Mr. W. Ingwersen writes, if all too briefly, of the many-sided attractions of these plants—something of their history as garden plants, from the sixteenth-century carnations and pinks to the many hybrids of recent production.

The species exhibit a narrow range of colour, if we exclude the yellow *Dianthus aridus* and *D. knappii*, which latter, despite the author's criticisms, can be attractive with appropriate culture and suitable setting. Many species have long been cherished for their perfume, whether it be the fringed and scented flowers of *D. superba*, the sweet fragrance of the white *D. squarrosus*, the massive odour of the clove carnations, the elusive scent of the Sweet William, or the pervading odour of *D. nolanus*. Distribution, propagation and hybridization are concisely dealt with, but most of the space is devoted to the species and garden hybrids about which the author writes with first-hand knowledge and imparts valuable experience respecting their culture. Not the least biologically interesting feature of perennial *Dianthus* species is their varied span of life from *D. alpinus*, which often survives only three years, to the long-lived *D. arboreus*.

The work is illustrated with some excellent flower portraits in black-and-white and some, mostly less excellent, portrayals in colour. The book is one that should be on the shelves of every *Dianthus* enthusiast, if only for the author's illuminating comments from a wide experience. E. J. SALISBURY

Engineering Science

By H. B. Brown and A. J. Bryant. Vol. 3. Pp. viii+531. (London: Macmillan and Co., Ltd., 1950.) 10*s.* net.

IN the scheme of instruction for national certificates in engineering, "Engineering Science" is a comprehensive subject which runs continuously through the three years of the ordinary course. In the third year, it comprises several branches previously treated as separate subjects, such as applied mechanics, hydraulics, strength of materials, theory of machines and heat engines. In many respects, this no doubt is an advantage as it ensures a broad foundation of knowledge being available for continued study or for application in practice, and gives the student a clearer perception of the essential unity of those branches of the subject.

One result of the syllabus is that it has made necessary a new type of text-book, and authors are presented with the problem of giving unity and balance to a treatise dealing with so many diverse phases and presenting them as a single logical subject. In the present volume, the authors have shown that this problem can be resolved within the scope of a convenient text-book. It is the third of a series designed to cover the three-year course in this subject, and graded to meet the student's attainments at each stage. In the third year the student has reached the calculus, and in this volume free use of it is made. Experimental work, testing and full-scale trials of prime movers have been given an important place, and the numerous examples have been carefully selected to give a practical association with the problems of design and operation towards which the reader is progressing. A notable feature of the presentation is the clear and concise way in which the descriptions and explanations have been given.

In addition to the requirements of the ordinary national certificate, its scope includes that of the engineering science course of the secondary technical school and also, in large measure, those of the syllabuses of the Institution of Mechanical Engineers examinations and others which demand engineering science as an integral part of their syllabuses. It should prove of considerable use to designers, draughtsmen and industrialists when questions of principle and application arise.

Chymia

Annual Studies in the History of Chemistry. Tenney L. Davis, Editor-in-Chief. (Edgar F. Smith Memorial Collection.) Vol. 2. Pp. x+144+21 plates. (Philadelphia: University of Pennsylvania Press; London: Oxford University Press, 1949.) 32*s.* net.

IN a foreword to this second volume of "Chymia", the editors announce that Tenney Lombard Davis, distinguished as an organic chemist and a master in the field of the history of chemistry, had passed away in the interval between its publication and that of the first volume, to which he gave much of his time and energy. All interested in the history of chemistry will feel the loss which science and culture in general have sustained in his death.

The present volume contains an interesting paper by him on the *pulvis fulminans*. There are also papers on such subjects as the alchemical interests of Newton (in which the publication of D. McKie on this subject should certainly have been mentioned), ambergris in India, the atomic theory before Boyle (in which no mention is made of the detailed study by Partington), and Sir Kenelm Digby, as well as others. The publication of successive volumes of "Chymia" continues to add to the high reputation which this series of studies in the history of chemistry has established.

J. R. P.

A Textbook of Colloid Chemistry

By Prof. Harry Boyer Weiser. Second edition. Pp. x+444. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1949.) 33*s.* net.

THIS is a review of colloid chemistry written mainly from the classical point of view and, within these limitations, is reasonably comprehensive. The discussion of modern techniques, such as X-ray diffraction and light scattering, is inadequate, and the reader will have to search elsewhere for useful knowledge on these topics. The documentation of the subject which, in the case of this second edition, is presumably carried to the later part of 1948, is presented in a somewhat one-sided fashion. The author has a praiseworthy grasp of American work but tends to neglect European, and particularly British, contributions to the field. These omissions detract from the value to a student of an otherwise pleasing book which treats a number of important aspects of colloid science with clarity and effectiveness.

Kleine Kryptogamenflora von Mitteleuropa

Von Prof. Dr. Helmut Gams. Band 1: Die Moos- und Farnpflanzen (Archegoniaten). Dritte verbesserte Auflage. Pp. iv+186. (Jena: Gustav Fischer, 1950.) 9.40 D. marks.

THIS excellent little book should be brought to the notice of all 'rucksack' travellers interested in the lower plants. It is a complete and usable guide to the liverworts, mosses and ferns of Central Europe, although in size it is scarcely larger than a British passport. In format it resembles Pascher's "Süsswasserflora". Thanks to Prof. Gams's experience as a teacher, the analytical keys are eminently usable. Diagrams are numerous and clear, and very great care seems to have been taken in the compilation of synonyms, which are extensively quoted, and in the provision of information on habitats and localities. The two previous editions came out in 1940 and 1948 respectively, so that this one is fully revised. For its size it is a very remarkable achievement, and will have uses far beyond the geographical area for which it was designed.

Organic Reactions

Vol. 5. Roger Adams (Editor-in-Chief). Pp. viii+446. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1949.) 48*s*. net.

THIS series of publications, invaluable to organic chemists, was begun in 1942, and the five volumes issued to date, containing altogether 1,740 pages, cover some fifty of the outstanding reactions of organic chemistry. The present volume follows the lines of the admirable scheme laid down at the outset, and the descriptions, documentation and tabulation conform to the high standard of accuracy and completeness characteristic of the series. The subjects of the ten chapters comprise the synthesis of acetylenes, cyanoethylation, the Gattermann–Koch and Leuckart reactions, selenium dioxide oxidation, the Hoesch synthesis, the Darzens glycidic ester condensation, together with further treatments of the Diels–Alder and Friedel and Crafts reactions and the preparation of organic fluorine compounds. JOHN READ

The Use of Geography

By Prof. Frank Debenham. (Teach Yourself Geography Series.) Pp. 206. (London: English Universities Press, Ltd., 1950.) 6*s*. net.

PROF. F. DEBENHAM has taken a rest from his more serious studies on the formation and growth of the Ross Ice Barrier and the water supplies of Central Africa, and allowed himself to play with anecdote and incident in the problems of academic geography from which he has recently retired. This little volume is mostly an introduction to a small series of geographies written by Cambridge men, each of which is to illustrate one aspect of the Cambridge school. It gives a rapid survey of the history of geography and shows the different approaches to the study of place.

While Prof. Debenham more than once assures us that he is all in sympathy with the human geographer, he succeeds in showing that his preference, in fact his creed, is on the physical side, including cartography. In these branches the Cambridge school excels. He seems a little suspicious of the human and social side, but he must admit that it is prominent in many university schools; and he does admit that Cambridge is not the only school. Perhaps as a concession Prof. Debenham allows the value of the individual student's regional essay in humanizing the physical basis. It is a most readable essay, for Prof. Debenham is never boring, but, as usual, is fresh, lively, full of ideas and tolerant of all opinions honestly held. As for the use of geography, the subject seems as much to interest and amuse us as to have any other end. But as taught by Prof. Debenham it could never be dull. R. N. R. B.

Theory of Knowledge

An Introduction. By A. D. Woozley. (Hutchinson's University Library, No. 33.) Pp. 196. (London: Hutchinson's University Library, 1949.) 7*s*. 6*d*. net.

HALF a century ago, the theory of knowledge was regarded as a very advanced subject, only discussed by fellows of colleges, a few canons residentiary, and a headmaster or two (of the ancient foundations). Not so to-day, however; for that fashionable universal, the plain man, apparently wants to study epistemology, and indeed he is fortunate to have a book like this to begin with. Mr. A. D. Woozley gives all the essentials of judgment, the correspondence and coherence theories of truth, and much else besides, with commendable clarity, and not a little wit. If a comment is allowable, it is that the amount of space devoted to memory seems a little excessive. But apart from that, the balance is masterly.

There are several illustrations from natural science, showing the value of discrimination in the use of evidence. This should appeal to university students, whatever their subject, as well as to the amateur. In addition, the approach is to some degree historical, which enables the reader to discern how some of the tenets, at first sight outrageous, came to be modified and tempered in the flame of continuous criticism. The proof-reading must have been first-class: I have noticed only two misprints, in fact the same one twice. F. I. G. RAWLINS

Structure and Development of the Vertebrates

A Manual for an Integrated Course in Comparative Anatomy and Embryology. By Prof. Florence Moog. (Prentice-Hall Animal Science Series.) Pp. xiii+170. (New York: Prentice-Hall, Inc., 1949.) 4.65 dollars.

THIS book is an interesting attempt to provide an integrated course built on the theory that "students should be thoroughly grounded in the essentials of embryonic form and development before plunging into the complexities of comparative anatomy itself". It is essentially a practical manual, but the subject-matter is dealt with more fully, and in a more interesting manner, than is usual in such books. The course begins with a study of the anatomy of the ammocœtes larva of *Petromyzon*, and then passes on to the embryology of the frog and the chick. Next follow two useful essays on homology and recapitulation, which serve as an introduction to comparative anatomy. This is discussed system by system, and there are also chapters on gametogenesis, fertilization and the placenta.

The standard most closely approximates to that of British sixth-form school, or first-year university, courses. However, while the novelty of the approach may attract some, the book is not closely adapted to British needs. The use of *Necturus* as a type limits its value; and, although the production is beautiful, it is sad to have to say that the artificiality of its price, the result of devaluation, is almost sufficient in itself to exclude it from British laboratories.

W. S. BULLOUGH

DATING THE PAST BY RADIOACTIVE CARBON

THE use of radioactive carbon for the estimation of the age of archæological objects has attracted widespread attention. At the recent Birmingham meeting of the British Association, it was the subject of a joint discussion of Sections A (Mathematics and Physics) and H (Anthropology and Archæology). Contributions were made by J. V. P. Long, F. E. Zeuner and K. P. Oakley. The method was conceived by Dr. W. F. Libby of the Institute for Nuclear Studies of the University of Chicago[1], and he and his co-workers have been able to design the necessary apparatus for the application of the method to certain types of archæological material.

Briefly, the method relies on the fact that neutrons from cosmic rays are captured by atmospheric nitrogen. The nucleus formed disintegrates immediately, casting out a proton, and a carbon atom of the atomic weight 14 is left. These atoms are radioactive and disintegrate by expelling an electron, the half-life being $5,568 \pm 30$ years[2,3]. With the expulsion of the electron the atom reverts to ordinary nitrogen of atomic weight 14. During their period of existence, the atoms of carbon-14 enter into the carbon dioxide of the atmosphere in much the same way as do the atoms of normal carbon (carbon-12 . The concentration of carbon-14 in the atmosphere is about 10^{-12} gm. per gram of carbon-12. Since carbon dioxide provides virtually all the carbon used by plants in building up their tissues, the isotopic composition of carbon in living vegetable matter must be the same as that of atmospheric carbon, and the same applies to living animals, all of which ultimately derive their body material from the plant kingdom. But once an organism is dead, it will no longer receive carbon of atmospheric composition, and its content of carbon-14 will disintegrate according to its half-life period. The proportion of carbon-14 to carbon-12 in dead organic matter, therefore, is a direct function of the time elapsed since the death of the organism, and this provides the means of dating the organism by isotopic analysis of its carbon.

Because of the very small quantity of carbon-14 present even in living organic matter, the apparatus used has to be extremely sensitive. Of the two possibilities of introducing carbon into the counter tube, either as carbon dioxide or in a solid form, Dr. Libby has favoured the latter alternative. It has been necessary to screen the apparatus very carefully from external sources of radiation, mainly from cosmic rays, which bombard the counter tube at the rate of about 350 counts per minute, while 1 gm. of carbon gives not more than about 12 counts per minute. The reduction of the background count, therefore, is a serious problem, which Dr. Libby has solved by arranging other counters around the carbon counter and by shielding the apparatus by sheets of lead and iron[3].

Mr. J. V. P. Long, of the National Physical Laboratory, Teddington, however, is optimistic about the possibility of using gas counters. While the screening precautions would obviously have to be the same, the preparation of the samples is simpler in the case of gas counters, and accuracy of the counts is likely to be higher according to Mr. Long's observations.

The carbon-14 method rests on a number of assumptions. Several of these, like the constancy of cosmic radiation throughout the period involved, are implied in its physical aspects. But apart from these there are some geological and archæological assumptions which deserve close attention. The first of these is that carbon-14 is evenly distributed in living matter. For example, Dr. Libby considered it possible that, because of the latitudinal variation of cosmic radiation, latitudinal differences may exist in the isotopic composition of the carbon in woods grown in different geographical latitudes. An assay of fourteen woods[4] has shown clearly that there is no such correlation with geographical latitudes. On the other hand, the range of results is considerable, which raises the question of whether carbon-14 may be taken up selectively by various species of organisms. This possibility can no longer be ruled out, since Nier[5] has recently found that, in the formation of carbonates, carbon-13 is favoured compared with carbon-12. He has also found that plants are relatively enriched with carbon-12 compared with carbon-13. What applies to carbon-13 might equally, if not more so, apply to the still heavier isotope carbon-14. It will be necessary, therefore, to study a much larger number of Recent samples than has hitherto been done, and it might even become necessary to compare samples of the same material only.

The second assumption is that unaltered samples are available. It may be safely assumed, for example, that specimens of wood taken from Egyptian rock tombs have preserved their carbon exactly as required and have not suffered contamination. But this does not apply to samples taken from open-air sites, where they have been exposed to weathering processes. This applies in particular to specimens of charcoal, which are otherwise very suitable for isotopic analysis. Charcoal is strongly adsorbent, and since solutions containing humic substances pass through the soil while weathering is in progress, charcoal is likely to adsorb quantities of substances which contain carbon of younger age than that of the charcoal itself. Similarly, a contamination with younger humic substances is liable to occur in peats. In such cases it will be necessary to beware of contamination and if possible to develop a cleaning process which extracts the adsorbed organic substances without affecting the original material.

Other sources of contamination are of a technical kind. It is obviously necessary to shield specimens from exposure to sources of radioactivity. But some rather elementary precautions are very easily overlooked. Thus, samples may have been treated with preservatives or wrapped in tissue paper, cotton wool, or anything that might add Recent carbon to the sample. A particularly dangerous source of contamination is fungal and bacterial growth on the specimen. It occurs very readily if specimens are packed in air-tight containers in a moist condition, as is often done by archæologists. The sample may afterwards be dried and all external evidence of the growth removed. Nevertheless, there may be enough Recent organic matter left in the sample to reduce its apparent age very considerably.

The third assumption is that the carbon of the sample was 'Recent' carbon at the time when the specimen became an object of archæological interest. This assumption may be erroneous in two very different respects. First, the material may have been old at the time when it was used. For example, wood, when made into an article by man, is not necessarily quite recent. Thus it is well known from the ring-counts carried out by Dr. Douglass and his collaborators in the south-western United States that beams, sometimes hundreds of years old, were used again and again in the construction of Indian pueblos. The use of old wood must have been very common in countries where this raw material was relatively scarce.

On the other hand, although the raw material may have been quite 'recent' at the time of its becoming an archæological specimen, the carbon of which it is composed need not always be 'recent' carbon of that time. It will almost certainly be nothing but 'recent' carbon in the case of vegetable matter, since plants derive their carbon from the atmospheric carbon dioxide. Molluscan shells, however, are a different matter. As they are often available in quantities in archæological sites, their calcium carbonate affords a good source of carbon for investigation. But it is not certain whether the isotopic constitution of such carbon corresponds to that of the atmosphere when the mollusc was alive. It may have taken up carbonates, for example, from Palæozoic limestone, and incorporated it in its shell. This adds a complication to the use of carbonates. In addition to the possibility of selective intake of carbon-14, as suggested by Nier's discovery of the favoured intake of carbon-13 in the formation of carbonates, very little is known about the processes of building up of molluscan shells. A special investigation may become necessary if the use of carbonates for carbon-14 age estimates is to be developed.

The ordinary method is restricted to the last 20,000 years, which can be extended to the maximum of 30,000 years by enriching in a thermal diffusion column[5]. It is virtually limited to the Late Palæolithic, Mesolithic, Neolithic and Bronze Age periods. Physicists are actively improving their apparatus and refining the analytical technique. According to Dr. Oakley's report, one of the troubles encountered by Drs. Libby and Arnold is the difficulty of removing completely the magnesium oxide from the carbon after its reduction from carbon dioxide. It has been solved for the time being by making a correction for unremoved magnesium oxide. It is, however, urgently necessary to study also the geological and prehistoric aspects of the method in order to eliminate the sources of error involved in the sampling. New developments may well emerge from such work. Thus, the use of flotation methods for the recovery of finely divided carbon from prehistoric hearths and occupation layers had been suggested, and Dr. Oakley stated that American workers have had some success using zinc chloride.

In spite of its limitations and difficulties, the carbon-14 method of dating promises to settle many outstanding chronological problems, such as the beginning of food production, and the first colonization of America. Some of these were discussed at the Viking Fund Seminar in Physical Anthropology held in June in New York, at which Dr. Oakley was present. The last (Mankato) advance of the Wisconsin glaciation passed over tree trunks the age of which by the carbon-14 method is of the order of eleven thousand years, that is, less than half the age expected by geologists. This is the time when man is believed to have first appeared in North America. Dates from occupation sites in the western United States are of the order of 7–10,000 years. In the eastern United States, the earliest cultures are proving to be later than in the west. Carbon-14 dates suggest that man spread there about five thousand years ago.

Check samples from sites in Egypt and Syria dated by historical evidence have produced satisfactory results[6]. Dr. Braidwood, of the Oriental Institute of the University of Chicago, has great hopes that the carbon-14 method will help in the dating of the appearance of agriculture in the Near and Middle East[7]. At the recent Zurich session of the International Congress of Prehistoric and Protohistoric Sciences, Braidwood reported on some preliminary results based on carbon-14 determinations, which seem to confirm the beginning of the First Dynasty of Egypt at about 3000 B.C., and that primitive agriculture was already being practised in the Kurdish hills at about 5000 B.C. F. E. ZEUNER

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LANDSCAPE EVOLUTION IN GREAT BRITAIN

AMONG the discussions at the Birmingham meeting of the British Association was one carried on by geographers and geologists (Sections E and C) on "The Pre-Glacial Evolution of the British Land Surface". This topic is one of real importance to both groups of workers. To the geographer seeking an explanation of the complex relationships which obtain between the different elements of the physical and cultural landscapes of his own country, some understanding of the stages by which the former developed is vital. The key to the role and relationships of soils, surface forms and ground-water conditions in the present landscape lies often in the phases of its past evolution. To the geologist concerned with elucidating the geological history of Britain, the record of the evolution of the land surface is a chapter which should not be ignored. Yet ignored or overlooked it certainly has been. Only in the volcanic districts of Antrim and the Hebrides in the north-west, and in East Anglia and the London and Hampshire Basins in the south-east, is there direct stratigraphical witness as to what was going on in Britain in Tertiary time, and geologists have therefore devoted themselves to the task of piecing together the record of earlier phases of our palæo-geography from the rich records of the Palæozoic and Mesozoic successions, or have devoted themselves to the complexities of the glacial, interglacial and post-glacial successions. As Prof. S. W. Wooldridge remarked in the course of his presidential address to Section E, "by a combination of physical chance and human perversity the Tertiary era has almost become a

neglected 'Dark Age' in the geological history of Britain". A joint discussion of geologists and geographers intended to throw light on the problems of this 'Dark Age'—which the radioactive clock tells us was sixty-five or seventy million years long—is therefore greatly to be welcomed, and if the lamps held up at Birmingham cannot be said to have cast their light very far into its depths, it is certain that their beams are turned in the right direction.

Geomorphology offers two contrasted and complementary lines of approach to the problem, namely, by the elucidation of denudation chronology and by the reconstruction of the original pattern of our drainage system. The latter is possible at all only by virtue of the fact that when a new cycle of erosion begins as the result of general uplift, the landscape inherits the rivers of the previous cycle unless these have been extinguished by a marine transgression. Not all the rivers so inherited will survive long, and not all of them belonged to the initial drainage pattern. But some of our present-day rivers may be older than any feature of our present land-surface, and in applying this method to the Midland region of Great Britain (in a very wide sense of that term) Prof. D. L. Linton made this claim for the North Welsh Dee where it crosses the Berwyn Hills, and for the south-flowing streams of the southern Pennines and notably the Derbyshire Derwent. From these and other surviving remnants he reconstructed a Proto-Trent, with headwaters as far west as Snowdonia, which flowed eastwards across the North Midlands receiving the Derwent and its analogues as left-hand tributaries, and the ancestors of the present north-flowing Penk, Tame and Soar from the right, and flowed into the North Sea beyond the site of the Wash. An east–west watershed, he argued, bounded this system from that of a comparable proto-Thames to the south, also carrying Welsh water to the North Sea, while to the north other workers have stressed the importance of the east-flowing element in the original drainage of Yorkshire, Durham and Northumberland, and even beyond the Border.

Later work in many parts of Britain will be necessary to establish such a reconstruction and to give it precision; but if it be allowed that the general pattern of our earliest rivers is being revealed, it becomes clear that the movements that brought it into existence comprised a widespread, though not uncomplicated, tilting from west to east. Prof. Linton would identify this movement with those known to have upraised the Chalk before the deposition of the basal Eocene strata of the London Basin, and if he is correct some new light is thrown on the earliest episodes in our Dark Age.

The later phases are better illumined by tracing the remnants of former valley floors or of base-levelled surfaces of wider extent. Such work must needs be detailed and precise, and therefore local, and the interim results of work being carried on in three widely separated areas—Exmoor, County Clare and the Derby–Staffordshire border—were presented by Mr. W. G. V. Balchin, Dr. Marjorie M. Sweeting and Mr. G. T. Warwick. Each has recognized a series of landscape features corresponding to periods of stillstand and has designated those periods by a non-committal local terminology. The question of correlating the stillstands of one region with those elsewhere had already been taken as far as it can profitably be taken at present by Prof. Wooldridge in his presidential address, and it was therefore not pursued. But a point that was taken up in general discussion concerned the question whether the surfaces at higher levels are marine or sub-aerial. Mr. Warwick's succession of inland stages is wholly sub-aerial, and Dr. Sweeting's partly so; Mr. Balchin's stages at comparable altitudes are all marine and regarded as successive strand-flats cut during the discontinuous emergence of south-western England from the sea. If this emergence is regarded, as it is by Mr. Balchin, as being due to a succession of eustatic drops in sea-level, a somewhat wholesale late-Tertiary submergence of the English lowland would seem to be implied—a conclusion not in accord with the drainage reconstructions so far made. The eustatic hypothesis is attractive, and by its aid some correlations at the lower levels—say, up to 650 ft. or 200 metres—seem to be in sight; but at higher levels the possibility of tilting of the older surfaces must be borne in mind. Prof. Dudley Stamp, in one of his now rare utterances as a geologist, underlined this point and urged the growing band of younger British geomorphologists to supplement the record of their own observed stages of erosion by the depositional record provided by the late-Tertiary succession of Holland. That record is one which implies warping or tilting of the areas to the west and south from which the deposited material came. It was fitting that the last and youngest contributor to the discussion—Miss Alice Coleman—should announce that work she is completing in East Kent displays evidence in the uniclinal shifting of the Stour and, by the discrepancies in altitude between the Kentish succession of stillstands and those worked out for the South Downs by Mr. B. W. Sparks, of eastward tilting during even the latest phases of landscape evolution.

It is evident that in this field of common interest to geologists and geographers a good deal of work is being done, chiefly at the moment by the geographers; and that as the body of evidence derived from the field-work grows, it will demand for its proper interpretation the experience and imagination of some of the best minds in both subjects. This joint discussion made a not inauspicious beginning.

D. L. Linton

NEW DISCOVERIES OF THE AUSTRALOPITHECINÆ

In 1946 there appeared a memoir of the Transvaal Museum by Dr. R. Broom and Dr. G. W. H. Schepers, in which were described the fossil remains of the Australopithecinæ discovered up to that date at Taungs, Sterkfontein and Kromdraai. In 1947 Dr. Broom, continuing his indefatigable search in the stalagmitic deposits at Sterkfontein, came upon a site which proved to be astonishingly rich in the remains of the Australopithecine group to which he had given the generic name *Plesianthropus*. A further memoir* provides a description of these new discoveries. The description, abundantly illustrated, is not intended to be more than a general account. Indeed, there is now so much material available for study that some years are bound to elapse before it can all be subjected to a complete analysis. Nevertheless, this preliminary

* Transvaal Museum Memoir No. 4. Part 1: Further Evidence of the Structure of the Sterkfontein Ape-Man *Plesianthropus*. Part 2: The Brain Casts of the recently discovered *Plesianthropus* Skulls. By Robert Broom, J. T. Robinson and G. W. H. Schepers. Pp. 117+8 pl. (Pretoria: Transvaal Museum, 1950.)

account, brief though it is, will be welcomed by all those anatomists and palæontologists who are concerned with the problem of human evolution, for it has become abundantly clear that Dr. Broom's discoveries are indeed very relevant to this problem. A ground-plan of the new Sterkfontein locus in the memoir shows that it is of quite limited extent, covering an area of about forty-five square yards. Within this restricted area have been found, closely packed together in the dense limestone matrix, the remains of eight skulls, three mandibles, portions of several limb bones (including a fine specimen of the pelvic skeleton) and very many teeth.

All this new Australopithecine material greatly extends our knowledge of these extinct ape-like creatures and also (it is important to note) vindicates in a remarkable way the provisional conclusions which had already been expressed by Dr. Broom and others on the basis of the earlier, more fragmentary, fossils. Thus, the hominid characters of the auditory region noted in the original Kromdraai skull have also been demonstrated to be present in the new Sterkfontein skulls. The hominid features of the occipital bone which had been observed in the Kromdraai skull and the type skull from Sterkfontein have been found to be consistently present in all the other skulls in which this region is preserved. The reconstruction of the frontal region of the type skull of *Plesianthropus* has been verified by the practically complete skull (No. 5) discovered at Sterkfontein in April 1947. The essentially hominid characters of the dentition are consistently repeated in all the newly discovered specimens of the teeth. The earlier inference (based admittedly on rather incomplete material) that the Australopithecinæ were equipped with limbs approximating very closely to those characteristic of man has received striking confirmation from further discoveries of limb bones and of the pelvic skeleton.

This last specimen deserves particular attention. It was actually found *in situ* in the midst of all the other Australopithecine remains derived from the same locus (and at the same level). It consists of a practically complete right os innominatum and also a portion of the left side. In the low broad ilium, the deep sciatic notch, the strongly developed anterior inferior iliac spine and a number of other features, the bone is essentially of the hominid type and (as Dr. Broom's comparative illustrations demonstrate very effectively) contrasts very strongly with the pelvic bone of anthropoid apes. Indeed, so human is the appearance of this bone, that some critics at first contended that it could not be part of an Australopithecine skeleton. The circumstances of its discovery, however, appear to discount this criticism, as well as the fact that it presents unusual characters which (so far as is known) are not to be found in any variety of *Homo sapiens*. It has further to be added that a second ilium of the same hominid type was later found at an independent site (Makapansgat) which had also yielded a mandible and portions of skulls of *Australopithecus*.

Lastly, yet a third os innominatum, excellently preserved and reproducing the same features of the Sterkfontein pelvis, has now been discovered at Swartkrans. The details of this fine specimen (which was also found *in situ*, within a few feet of two large Australopithecine mandibles) have not yet been published, but a photograph exhibited on behalf of Dr. Broom and Mr. J. T. Robinson at the International Anatomical Congress recently held at Oxford demonstrated very clearly its main features. The fact that three specimens of the Australopithecine pelvis have now been found at these independent sites, and that they are all of a predominantly hominid type, leaves no further room for doubt that the posture of the Australopithecinæ must have approximated quite closely to that characteristic of the Hominidæ. This evidence of the pelvis is consistent with that of the other limb bones the remains of which have been discovered by Dr. Broom, and also with the less direct evidence provided by the basal region of the several skulls now available for study.

Without doubt, the most important result of all the recent discoveries at Sterkfontein and elsewhere is that they eliminate any further need for relying for comparative or statistical study on single, isolated specimens which, it might be argued, are perhaps of an exceptional nature. Attempts have already been made (somewhat prematurely, as it seems to me) to subject to statistical analysis some of the limited and very fragmentary Australopithecine fossils discovered several years ago, and certain inconclusive results (based on measurements taken at second hand or made on plaster casts) have unfortunately led to controversies which the much more abundant evidence since become available now show to have been unnecessary. Thus, well over two hundred teeth of the Australopithecinæ have now been recovered, providing a much more reliable series for the study of variability than the first few specimens which have been used for this purpose. The great accession of new material also makes it possible for the first time to compile satisfactory data regarding the degree of uniformity in the distribution of individual characters, or combinations of characters, in the Australopithecine population. It can now be stated, for example, that nine out of nine palates consistently present evidence of a combination of hominid features in the upper dentition which has not been demonstrated to exist in any anthropoid ape even as an exceptional condition, that four out of four immature jaws with the milk dentition consistently show that the deciduous canines and first molars conform to the human (and not the ape) pattern, that more than a dozen specimens demonstrate that the permanent canines (presumably of both sexes) were consistently small and of human type and associated with no diastema, that seven out of seven anterior lower premolars show the non-sectorial bicuspid form distinctive of the hominid dentition, and so forth. These are a few examples which could well be multiplied.

Thus, it may now be accepted that, in the totality of their morphological features, the Australopithecinæ certainly resembled primitive hominids much more closely than do any of the known anthropoid apes. The significance of this fact is, of course, open to interpretation. Dr. Broom and Mr. Robinson express themselves carefully on this point, but they suggest (and the suggestion is one which seems best to fit the facts so far as these can be assessed at present) that the Australopithecinæ either represent a branch of the ancestral stock from which *Homo* was derived, or are at least rather closely related to this stock. One of the outstanding features of the group is the small size of the brain (as indicated by the study of endocranial casts). There is reason to suppose, as Dr. Schepers points out, that the brain in relation to the size of the body may in some cases have been some-

what larger than that of the anthropoid apes of to-day, but the evidence of the Sterkfontein fossils evidently does not permit a firm statement on this point. On the other hand, the more recent discoveries by Dr. Broom of larger Australopithecine skulls at Swartkrans (photographs of which were also exhibited at the International Anatomical Congress) have raised anew the possibility that the size of the brain extended its range beyond that recorded for the gorilla and chimpanzee, and perhaps even came within the range of primitive hominids of the *Pithecanthropus* group.

W. E. Le Gros Clark

QUALITY IN GRASSLAND

A DISCUSSION on "Quality in Grassland" in Section M (Agriculture) of the British Association, held on August 31 during the Birmingham meeting of the Association, was opened by Dr. William Davies, director of the Grassland Research Station, Stratford-on-Avon. His remarks were followed by a short paper presented by Dr. D. H. Curnow, of the Courtauld Institute of Biochemistry, London, who dealt with œstrogens in grassland.

Dr. Davies suggested that rather than speak of quality in the singular, we should speak in the plural and discuss the 'qualities' of grass much as we speak of 'qualities' in man. Although most people have a working knowledge of what is meant by quality or qualities, it is, however, extremely difficult to provide a clear and concise definition of either quality or qualities. Among the qualities of grass and of grassland which were discussed were, first, the production of nutrients spread over as long a season of the year as possible; and the point was made that we here deal with quality as it is affected by high production of freely available nutrients. Because of the concentration of digestible nutrients in the leaf, it is clear that one of the first qualities of good grassland is that it is leafy as well as being at high production over a prolonged season of the year. Young actively growing leaf is of better quality than leafage of slower growth, while it may be shown that leaf tip is of better quality than leaf base. Actively growing leafage is usually of better quality than old and mature leafage. Leaf lamina has qualities that are superior to leaf sheath (in the grasses) or petiole. Stem even when immature is of lower quality than leaf.

Evidence from current researches being conducted at the Grassland Research Station and elsewhere in Great Britain shows that herbage can be produced for consumption *in situ*, even in the middle of winter. It is becoming clear, however, that winter grass has qualities which are distinctly different from those of spring-grown grass. These differences may be associated with the high fibre content of winter grass and with a lower energy-value than similar grass grown in spring. The nitrogen content of leaf lamina in winter is frequently higher than in summer. The feeding of pasturage *in situ* during the winter, therefore, may mean that, in the case of the high-production animal, in any event, carbohydrate of low fibre and of high energy-value might well be the sensible supplement. Indeed, there is some evidence to suggest that a carbohydrate supplement might be sensible, even at the height of spring flush.

Grass, using the term as embracing the legume and the herb, as well as the true grasses, is the cheapest and probably the healthiest form of animal feeding-stuff, particularly when grazed *in situ* by the animal itself. The farmer, therefore, is intensely interested in any technique which is practicable and will extend his grazing season. Grazing out of doors during the wet and inclement weather of winter clearly creates new problems for the farmer, but none of these seems to be insoluble. The work of the grassland technician is to examine critically the practical problems associated with the utilization of grass grazed *in situ* during the winter to provide the practising farmer with a technique both of production and of utilization of winter grass.

It is by no means certain that fibre content, energy value and nitrogen-level in the dry matter are the only distinctive differences between summer and winter grasses. Future investigation may indicate other differences, such as, for example, in œstrogen content or in the content of vitamin precursors, mineral value, and so on. There is here a wide and largely uncharted field of study, not only for the agronomist and animal husbandryman, but also for the biochemist and veterinarian.

It is a fairly simple observation that as grass, in its widest context, matures, so its quality deteriorates. Every herbaceous plant goes through a period of maturation from the time it starts growth in spring to the time when it has produced flower and seed. During this period the plant increases in dry weight but decreases in quality as measured by its nitrogen content (which gets lower) and its fibre content (which gets progressively higher). The farmer attempts to prevent this maturation taking its normal course when he grazes his grassland and maintains it in a leafy condition for as long as possible.

The ruminant animal is the largest aggregate consumer of the grass crop. It is abundantly clear that the animal at high production demands grass of high quality. Grass, however, may not be the perfect food for animals at a high level of production, for it may well show deficiencies such as those to be associated with straightforward lack of energy-value. The ruminant animal, however, can deal efficiently with leafage which may have a fibre content of 17 per cent or more. The non-ruminant, on the other hand, such as the pig and the hen, may well be found to show ability to utilize the grass crop. To do this effectively, and for grass to be a major element in its diet, we must provide herbage not only of high nitrogen content and of high energy-value but also especially herbage of low fibre-content. Here we must set the problem not only to the agronomist but to the plant breeder also. It should be possible for the plant breeder to select herbages in which the fibre content of the leaf lamina is as low as 10 per cent of the dry matter, and we should aim at material of even lower fibre content.

Another aspect of quality in the grass crop is that relating to mineral content. We know from the pioneer work of Prof. T. W. Fagan and others that many of the herbs of our pastures are extremely rich in minerals, especially calcium, phosphoric acid and potash. There may be other good attributes in the herbs when compared with the more normal grasses and clovers of Britain. For example, many of the herbs are sought after by the grazing animal, and further, what is true of the major elements mentioned may also be true of the trace elements. In this field, however, there is a great lack of critical evidence in so far as it relates to British herbage plants.

One of the qualities of the grass/legume sward is that it seems to improve soil condition and is acknowledged to increase the fertility of the soil, or at least to promote some benefit whereby arable crops in the rotation become more thrifty and more productive. Here again there seems to be an extraordinary lack of sound experimental evidence. We can infer, however, with some degree of confidence that the farmer who has been able to introduce the long ley into his farming system achieves a soil which works easier and better, and he raises the general level of his crop yields. One of the good qualities to be looked for in the grass crop, therefore, is abundant root development, which in turn fosters an improvement in soil condition and in level of crop production. Much work is urgently required in this connexion, not only in the agronomic field but also in associated fields of scientific endeavour. We need to know, for example, the influence not only of different grasses, legumes and herbs upon soil fertility, but also the influence of different systems of management of the grass crop and the part they play in building up the soil. Similarly, what is the long-term influence of different mineral products upon the soil, as well as upon the crops that are grown ?

No discussion on quality in grassland would be complete without reference to the qualities of the accepted fattening grassland of the Midlands and elsewhere in Great Britain. What is the fundamental difference between the so-called fattening and non-fattening land ? Clearly, any land is capable of fattening a bullock if that bullock can be maintained at a uniform level and reasonably high plane of nutrition throughout its fattening period. In the case of fattening land, the accepted practice is to turn the cattle beast out to grass in April and, without any purposeful management, that animal may be expected to be fat soon after midsummer almost irrespective of weather or season. In the case of non-fattening land, however, to achieve the same result in the fattened animal, one needs to plan the grazing in such a way that the animal is moved from pasture to pasture and assured of an abundance of high-quality feed which will maintain the animal at a high level of nutrition. From the scientific point of view, therefore, the distinction between fattening and non-fattening land is not a fundamental one and is in no way absolute. If the fattening animal is kept at a constant high plane of nutrition during the whole of its fattening period, then it should be possible to fatten on any land in Great Britain.

Dr. Curnow's paper on the œstrogens of grass was extremely informative. There is here clearly an important field of study which may have wide practical consequences. The technique of isolating the various œstrogenic compounds, and of relating each of them to the animal and its nutrition, remains to be worked out in detail. The observed facts are that, in Western Australia for example, excessive œstrogen occurring in a diet largely based on subterranean clover produced serious ill-effects in sheep of both sexes. Investigations in progress have shown that œstrogenic compounds are commonly found in a range of the native herbage of Great Britain, although normally not to the extent found in Western Australia. So far, little or no ill-effects have been observed in Britain, but work at the Courtauld Institute in London and at the National Institute for Research in Dairying at Reading is clearly important and aims in part at determining the role of the œstrogens in animal nutrition.

In the lively discussion which took place after the opening papers, Sir James Scott Watson indicated the practical difficulties of breeding in both the cow and the ewe so as to make use of the greater production which we can now expect from the grasslands of the world. This is a point of enormous importance, as it refers not only to our potential in lowland districts, but also to the problem of hill and marginal land. Dr. Norman Wright indicated, however, that the need for more production from grassland in Britain is immediate, if only to reduce our annual requirements of imported feeding stuffs. If properly utilized, grasslands in Britain can provide the bulk, if not the whole, of our protein requirements for cattle foods ; although we might have to import a certain proportion of low-fibre carbohydrates. Colonel J. A. Symon raised the important question of winter grass, and indicated that the problem on the farm is always to balance any extra summer carrying-capacity by an adequacy of good winter feed. Dr. R. E. Slade suggested that our level of manuring in general practice is not nearly high enough, and that with an improvement in our manurial practice and an increase in the amount of plant foods applied to the soil our grasslands would produce not only more dry matter per acre, but also more leaf, and leaf of better quality. He drew the important distinction between leaf protein and seed protein. Prof. H. D. Kay (president of Section M) closed the discussion by indicating that the animal protein factor might still prove a very important one, although speakers had suggested that a factor biologically equivalent to the animal protein factor may well be present in the leaf of high-quality herbage. WILLIAM DAVIES

PLANETARY ATMOSPHERES

A GEOPHYSICAL Discussion was held under the auspices of the Royal Astronomical Society during its recent visit to Dublin. Prof. L. W. Pollak, of the Dublin Institute for Advanced Studies, presided, and the general subject considered was "Planetary Atmospheres", although, as will be seen, no very strict limitation to the problems discussed was really observed. Prof. Pollak, in his opening remarks, directed attention to the fact that the occasion was perhaps a historic one, since it was, so far as he knew, the first time a meeting of this nature had been held in Dublin.

As a preliminary to the main discussion, Mr. R. Naismith, of the Radio Research Station, Slough, showed a research film entitled "The Ionosphere". The film illustrated the short-period changes in the heights and degrees of ionization of the various ionospheric layers, and showed clearly the great advantage of this method of presentation of scientific data in giving a coherent picture of comparatively slowly fluctuating phenomena.

The discussion proper was opened by Prof. J. H. J. Poole, who spoke on the origin of free oxygen in the earth's atmosphere. Prior to 1924, Jeffreys suggested that the constituents of the primitive atmosphere, including all the water of the hydrosphere, were originally held in solution in the once liquid earth, and only emitted to form an atmosphere during the

final solidification of the crust. Harrison Brown's work on the terrestrial and cosmical abundances of the rare gases has recently confirmed this view. It is highly improbable, as Jeffreys points out, that the gases emitted from the crust contained any free oxygen, but consisted mainly of water, carbon dioxide and nitrogen. Three theories have been advanced to explain the subsequent production of free oxygen, namely: (1) evolution of free oxygen from carbon dioxide by green plants during photosynthesis; (2) thermal dissociation of a small percentage of the dense water-vapour atmosphere present before the condensation of the ocean, and the subsequent escape of hydrogen into space due to the high atmospheric temperature (Tammann, 1924); (3) photochemical dissociation of water-vapour by solar radiation in the upper layers of the atmosphere, and the escape of hydrogen due to the high temperature of these layers (J. H. J. Poole, 1941; P. Harteck and J. H. D. Jensen, 1948).

Prof. Poole believes that while the bulk of the geochemical evidence shows that the main production of free oxygen was due to photosynthesis, it is necessary to assume that some free oxygen has been initially produced by a non-biological process to enable photosynthesis to start. He then briefly discussed the other two proposed mechanisms. It can be shown, if an isothermal atmosphere is assumed, that the period between the formation of the surface crust and the condensation of the ocean must have been very short, of the order of a few years. This need not be considered to be a fundamental objection to Tammann's theory, since the escape of hydrogen at the assumed initial temperature of 1,200° C. would be very rapid. A more serious objection can be raised, however, to Tammann's tacit assumption that the temperature of the exosphere of the earth was comparable with that of its surface during this period. Milankovitch, basing his argument on an equation due to Schwarzschild, has concluded that the original water-vapour atmosphere would have been in convective equilibrium, and consequently that when the surface temperature was 1,200° C., the earth was surrounded by a dense layer of clouds at a height of about 200 km. and a temperature of about 100° C. If this conclusion is correct, Tammann's theory must be invalid, since the rate of escape of hydrogen would be too slow. Prof. Poole considered that further investigation of this point is required, since Milankovitch's theory leads to the peculiar paradox that the hotter the surface of the earth was, the slower it cooled. This is due to the fact that, as the earth cools, the cloud-level falls and the cloud-temperature increases, and therefore presumably the loss of heat by radiation increases.

As regards the photochemical dissociation theory, the necessary conditions of high exospheric temperature and the presence of solar radiation of sufficiently short wave-length seem to be satisfied for the existing atmosphere. The danger of concluding, however, that this would also be true for the primeval atmosphere, before the start of photosynthesis, was emphasized. The temperature distribution above the tropopause is considered at present to be mainly due to the photochemistry of oxygen and the rarity of triatomic molecules, so that obviously conditions in an atmosphere consisting of carbon dioxide and nitrogen might be very different, and it seems probable that the exospheric temperature would be considerably lower. To give any estimate of the rate of production of oxygen even in the present atmosphere seemed to Prof. Poole to be impossible, owing to lack of knowledge of the amount of water present and the intensity of light of the requisite wave-lengths. Jensen and Harteck have tackled this problem by calculating, on certain assumptions, the rate of diffusion of water-vapour into the *E*-layer, and assuming that this figure gives the rate of production of oxygen. By this method they claim to have shown that the proposed mechanism could, in a period of 3,000 million years, have produced more than fifty times the existing amount of atmospheric oxygen. This result, however, is perhaps doubtful, and possibly only gives a major limit.

Prof. Poole concluded by remarking that improved *V2* rocket technique might enable us to test this theory by actual investigation of the concentration of hydrogen in the high levels of the atmosphere above, say, 150 km.

Mr. F. Hoyle spoke on the origin of the lunar craters. He maintained that, on recent cosmological theory, the moon during its early life must have suffered numerous collisions with meteorites, and that consequently the lunar craters must be due to these collisions. If this deduction is true, the craters should be fairly uniformly distributed over the surface of the moon; but, as a matter of fact, certain areas of the moon, previously considered to be seas, have no craters. T. Gold has advanced a theory to explain this fact. He considers that these areas are regions of low gravitational potential, corresponding to the ocean basins of the earth. He then assumes that owing to the rapid changes of temperature of the moon's surface, very fine dust particles, of diameter about 100 A., are eroded from the higher levels of the moon. These particles, under the combined action of attractive gravitational, and repulsive electric forces, tend to collect in areas of low gravitational potential, much as water on the earth collects in the ocean. The consequence is that the so-called seas are really areas which are covered to a depth of perhaps four or five miles with a layer of dust effectively concealing the craters present beneath.

Perhaps the most interesting contribution to the discussion was given by Dr. D. H. Menzel, who spoke on the atmosphere of Mars. He prefaced his remarks by expressing the hope that by making a strategic retreat to this planet, he might ensure for himself a fairly peaceful passage in the ensuing discussion. Dr. W. Wright, of Lick Observatory, found, about twenty-five years ago, that photographs of Mars taken in ultra-violet light show practically no detail as compared with those taken in red light. The diameter of the planet in the ultra-violet photographs also appears to be larger. For many years astrophysicists have found difficulty in explaining this effect, since an atmosphere dense enough to obscure the centre of the planet's disk in the ultra-violet should scatter red light near the edge of the disk, where the effective depth of the atmosphere would be much greater. Consequently, the ultra-violet and red images should be of equal diameter, and the central area of the planet should appear bluish in colour. Dr. Menzel stated that he pointed out this fact twenty-five years ago, and then doubted the reality of Wright's observations. Despite his scepticism, however, he was afterwards admitted to Lick Observatory, and since then has become convinced of the validity of Wright's results. He now attributes

the larger ultra-violet image to a thin cloud layer of carbon dioxide crystals which exists at a height of about 100 km. in the Martian atmosphere due to the temperature at this height being about 100° K. This layer would be capable of scattering ultra-violet light, but is transparent to red light, and thus accounts for Wright's observations.

Dr. Menzel then referred to the scarcity of water and the absence of oxygen in the Martian atmosphere. He considers that the polar caps consist of a very thin layer of ice crystals, perhaps only a fraction of an inch thick. During the long Martian summer the polar cap evaporates by sublimation without melting, and the actual surface temperature in the area of perpetual daylight may rise to about 20° C., the corresponding winter temperatures ranging from about −30° C. to −90° C. The atmosphere is usually very clear, but thin clouds have been observed to form in the late afternoon, and disappear during the early morning shortly after sunrise. These clouds are probably composed of fine ice crystals. An observer on Mars would see a deep blue sky with violet-coloured clouds forming at sunset.

Dr. Menzel concluded by referring briefly to the possibility of the existence of life on the planet. He considers that while the existence of higher animal types of life similar to terrestrial forms is unlikely, it is possible, as G. P. Kuiper has previously noted, that some simpler forms of vegetation, such as lichens, may do so. This would account for the seasonal change in colour observed in certain dark Martian surface features.

Space can be found here for mention of only a few of the many interesting points raised by the subsequent speakers. Dr. E. Opik considered that owing to infra-red absorption, the temperature of the carbon dioxide cirrus must be nearer that of the Martian surface (190° K.) than the postulated 100° K. required for its formation. Dr. Menzel agreed that this seemed an objection, but pointed out it might also apply to temperature problems in the earth's atmosphere. Dr. H. H. Poole and others raised the question of the possible origin of repulsive electric fields on the moon. Friction between the dust particles and the moon's surface was suggested, but an attractive, not a repulsive, force would be produced in this way. It was finally decided that a repulsive force could only be produced by both the particles and the moon's surface becoming positively charged through the emission of photo-electrons. Several speakers doubted the meteoric theory of the formation of the craters on observational grounds, and also maintained that the seas present the appearance more of extensive basaltic lava flows, rather than of presumably featureless dust surfaces.

Prof. W. M. H. Greaves raised the problem of the absence of free oxygen from other planetary atmospheres. Prof. Poole considered that for the major planets this is due to the fact that these planets have been able to retain hydrogen, and that for Mars and Venus it is caused by the absence of water. Dr. Menzel stated later, however, that he is not convinced that water does not occur on Venus, and he attributed the negative spectroscopic evidence to the occurrence of water as hail in a convective atmosphere. He pointed out that Lyot's observations on the polarization of the light from Venus seems to indicate that the clouds are composed of water, and mentioned that further work on this problem is being undertaken at the Lick Observatory.

Mr. Hoyle considered that the absence of free oxygen in the original atmosphere would not prevent the formation of an ionosphere. He further maintained that Tammann's theory must be rejected, because it would have supplied too much oxygen; and hence the theory really proved that no water was present in the original atmosphere, and that all the hydrogen contained in the existing oceans has been captured later by the earth from space, the oxygen required to form water being derived from the atmospheric carbon dioxide.

THE WORK OF THE MOTOR YACHT *MANIHINE*

By N. B. MARSHALL

Dept. of Zoology, British Museum (Natural History)

SINCE the summer of 1947, Major H. W. Hall, owner of the motor yacht *Manihine*, has placed this vessel at the frequent disposal of the British Museum (Natural History) for the purpose of marine biological investigations. In British waters work has been almost entirely confined to the English Channel, more particularly to the lesser-known eastern half. Besides adding to the national collections, these cruises over a period of four years have done much to increase our knowledge of the composition of the bottom fauna and summer plankton of the eastern Channel. Samples of this plankton have been made available to the Marine Biological Laboratory at Plymouth, while from time to time work has been undertaken for the Fisheries Laboratory, Lowestoft.

During the winter of 1948–49, the *Manihine* was concerned with a hydrological and biological survey of the little explored Gulf of Aqaba in the northern Red Sea. Reports of this survey are now ready for publication. It is planned to extend this work during the coming winter to the Sudanese Red Sea. The biological work will mainly consist of routine plankton hauls, trawling and dredging (if the character of the sea floor permits), fishing by line and collections along the coral reefs. As in the earlier survey of the Gulf of Aqaba, observations will be made on surface and sub-surface temperatures and salinities. Records from a deep-water bathythermograph will also be taken.

It may reasonably be expected that the results of the forthcoming work in the Sudanese area, together with those obtained earlier in the Gulf of Aqaba, will add considerably to our knowledge and understanding of the marine fauna of the Red Sea. In particular, it is hoped to learn something of the nature and extent of the deep-water fauna, which is at present not well known. There are, for example, records of only three species of bathypelagic fishes from the Red Sea. How far the shallow sill at the southern end may act as a barrier to the immigration of bathypelagic forms has yet to be determined.

It is the problem of barriers and the possible limitation of genetic interchange between Red Sea and Indian Ocean forms which makes a study of the fauna particularly interesting. The Red Sea is, geologically speaking, a relatively young sea. Its present connexion with the Indian Ocean, from which the greater part of its fauna has been derived, is thought to be about nine to ten million years old.

To-day the entrance from the Indian Ocean is by way of the narrow Straits of Bab El-Mendeb, inside which lies a shallow sill having a maximum depth of about 100 metres. Climatic conditions and the basin-like profile of the Red Sea are the predominating factors controlling the hydrological conditions, salinities and temperatures being generally higher than those in the Gulf of Aden, while, in contrast to the open ocean, there is no great difference of temperature between the surface and the bottom layers of water. These physical features may well mean that the Red Sea fauna is (and has been) isolated to a considerable degree, this having favoured the evolution of new forms. There are certainly good indications from earlier work and the survey in the Gulf of Aqaba that the Red Sea contains a considerable number of indigenous sub-species and species. There is therefore the expectation that continued study of the fauna of the Red Sea and detailed comparison with that of the Indian Ocean will not only indicate something of the extent and direction of evolution but will also permit some correlation with the time factor.

OBITUARIES

Sir Alexander Rodger, O.B.E.

THE death of Sir Alexander Rodger on September 30 last at the age of seventy-five brings to an end a fine career in the best traditions of forestry work.

Rodger was educated at Blair Lodge School and from there passed into the Royal Engineering College, Coopers Hill, in 1895. He obtained a diploma in forestry three years later and went out to Burma, where he served until 1911. In the latter year he was appointed instructor at the Forest College, Dehra Dun, and forest economist in the new Research Institute which had been inaugurated by Lord Curzon in 1907. He returned to Burma in 1913, and during the First World War was deputy controller for timber supplies under the Munitions Board, having charge of the large shipments of timber that went from Rangoon for India and the Middle East. He received the O.B.E. in recognition of his good work.

Rodger acted as conservator of forests in Tenasserim during 1920–22 and then was sent home in charge of the Burma exhibit to be erected at the British Empire Exhibition at Wembley. As will be remembered, the Burma exhibit became one of the principle objects of interest at that great Exhibition.

After some leave at home, Rodger returned to India as president of the Forest Research Institute and College at Dehra Dun early in 1925. In the following year he was appointed inspector-general of forests to the Government of India, this being the first time these two posts were held by one man. As a result of the fine work done by the new Research Institute during the First World War, at its close the Government of India had sanctioned the construction of a very much larger Institute and new buildings, and these were opened by the Viceroy of India in November 1920, Rodger at that time receiving the honour of a knighthood.

Among official publications for which he was responsible Rodger wrote "The Handbook of the Forest Products of Burma" and also undertook the publication of the second edition of Lace's "List of Trees and Shrubs of Burma". He retired from the Indian Forest Service in 1930 and served as a member of the Forestry Commission in Great Britain during 1932–39 and acted as external examiner in forestry at the University of Edinburgh during 1931–35.

Rodger will be long remembered in Burma, as he did great work for the forests of that country; he will be equally well remembered at the Forest Institute at Dehra Dun, where his enthusiasm was an inspiration to all those who worked there with him and under him.

E. P. STEBBING

Commander Vernon Edwards

VERNON EDWARDS died suddenly on September 22 at the age of fifty-nine. He was educated at Weymouth College, where he distinguished himself at athletics, particularly at Rugby football, and, coming from an old naval family, was himself intended for the Navy. However, he did not enter the Service until 1914, when he was gazetted a paymaster sub-lieutenant R.N.R. and served with the Sixth Light Cruiser Squadron throughout the First World War in the North Sea and Mediterranean, and afterwards in the Baltic. On demobilization Edwards found some difficulty in settling down in civilian life, and among other things he tried farming.

By a fortunate chance, while staying with relatives in Sussex, he met the late Dr. F. A. Bather, then keeper of geology in the British Museum (Natural History), who was much taken by the coloured toys, mostly animals, which Edwards made in his spare time. Bather at this time had a scheme for making 'cut-out' restorations of extinct animals, mostly dinosaurs, for distribution to local museums, and Edwards was asked to carry out the work. The scheme was not a very successful one from Dr. Bather's point of view, but it started Edwards on his career. From cut-outs of other people's restorations he quickly passed to original models of his own, and in these he was extremely successful for, although almost entirely self-taught both in art and anatomy, he had the remarkable gift of making 'dry bones live', at the same time taking the utmost pains to ensure accuracy. The first models were mostly of dinosaurs and Tertiary mammals; but in 1931 he was asked to make a series of dioramas for the fossil fish gallery in the British Museum (Natural History). There were eight of these and they were most effective. Thereafter dioramas and restoration-scenes became his chief work, while at the same time he extended his field to include historical subjects. Apart from the large series of his palæontological works in the British Museum (Natural History) and the historical dioramas in the Tottenham Museum, examples of Edwards's work have been acquired by museums all over the world. Recalled to the Navy in 1939, he served throughout the Second World War as Commander (S.) at sea in the North Sea and Mediterranean, and afterward, ashore in Ceylon, Mauritius and East Africa; but the heavy work put a great strain on him, and although he continued his modelling after the War he suffered from increasing ill-health.

Edwards was a cheerful, generous, kindly man, without a trace of malice in his make-up, and he will be greatly missed by his friends in scientific and other circles. He is survived by his wife and a married daughter.

E. I. W.

NEWS and VIEWS

Scientific Council for Africa South of the Sahara

THE Scientific Council for Africa South of the Sahara, the functions and composition of which were approved at an inter-governmental meeting held in London last May, will meet on November 21 at Nairobi for discussions on the utilization of science for the benefit of the subcontinent. The governments represented are Belgium, France, Portugal, Southern Rhodesia, the Union of South Africa and the United Kingdom and Colonies. The Council is constituted as follows: Dr. P. J. du Toit, president of the South African Council for Scientific and Industrial Research (*chairman*); Prof. J. Millot, director of the Scientific Institute, Madagascar (*vice-chairman*); Dr. E. B. Worthington, scientific secretary to the East Africa High Commission (*secretary-general*); Prof. Aubert, director of pedological research, Office of Overseas Scientific Research, Paris; Dr. F. J. Cambóurnac, Institute of Tropical Medicine, Lisbon; Dr. B. A. Keen, director of the East African Agriculture and Forestry Research Organisation, Nairobi; Dr. J. P. Lebrun, secretary-general of the National Institute of Agricultural Research in the Belgian Congo; Dr. A. Mendes Correa, of the University of Oporto, director of the Higher Colonial College, Lisbon, and member of the Portuguese National Assembly; Prof. T. Monod, director of the Institute of French Africa, Dakar; Col. W. H. Mulligan, director of the West African Institute of Trypanosomiasis Research, Kaduna, Nigeria; Dr. B. F. J. Schonland, research professor of geophysics and director of the Bernard Price Institute, University of the Witwatersrand, Johannesburg; Mr. N. P. Sellick, director of research, Meteorological Services, Salisbury, Southern Rhodesia; Dr. L. van den Berghe, director of the Institute for Scientific Research in the Belgian Congo. The Council's functions will be to suggest new subjects for research and how to set about them; to link in friendly liaison (but not to supervise) scientific bureaux now working in this field, as well as individual research workers; to facilitate transfer of these workers from one territory to another, and the circulation of their reports, and to suggest, to the governments concerned, such specialist conferences as may advance the interests of Africa.

Presenting Science to the Layman

IT is very generally accepted that in the United States the art of successful popularization is well understood, not only of knowing how to catch the attention of the ordinary man, but also in the even more important sense of knowing how to apply scientific theories and methods to the problems that interest him and in ways which he can understand. The July and August issues of the *Annals of the American Academy of Political and Social Sciences* (from the Academy Office, Philadelphia; 2 dollars each), dealing with the 'Point Four programme' and gambling, respectively, demonstrate this point very clearly. Each of the issues is in the nature of a symposium, for which special editors are appointed, and each contains a wide variety of articles which deal with a subject of public importance from the more popular as well as a strictly scientific point of view. The result cannot but be of great interest to the British reader, accustomed as he is to assume perhaps rather too readily that his own professional publications which deal with scientific topics cannot have more than an indirect effect on public opinion. This method of analysing a problem, and of presenting the results, is best demonstrated by citing examples from these two issues of the *Annals*. The discussion of the problem of gambling, for example, contains both a carefully prepared discussion of the psychodynamics of gambling, which is not likely to be understood by the ordinary reader, and also much more palatable articles, as, for example, that on gambling odds, prepared by a well-known statistician. The issue which is concerned with the Point Four programme similarly deals with the political, psychological and economic aspects of American aid to underdeveloped countries from a strictly technical point of view, and also provides a summary of the implications of the scheme as seen by competent British and United States experts and others with more general interests.

Work of the Caribbean Commission

SOME of the activities of the Caribbean Commission, a consultative and advisory body to further and co-ordinate economic and social progress in those territories within its scope (including the British West Indies), were indicated by the Minister of State for the Colonies in a reply circulated in *Hansard* for May 24. The Technical Information Services answer technical inquiries over a wide field, as well as producing and circulating information leaflets, the "Yearbook of Caribbean Research", "Crops and Livestock Information", reports on plant and animal diseases and educational films. Technical conferences have been held on land tenure, forestry, meteorology, livestock and soil science. Surveys and studies have been made in plant and animal quarantine legislation, industrial development, the criteria for potential Caribbean industries, fishery population movements, and the utilization of sugar by-products. Assistance in social and economic development has included aid to pioneer industries, tourist development and the administration of the war-time Caribbean schooner pool. The Commission is also the parent body of the Caribbean Research Council and the West Indian Conference which meets once every two years. Recommendations of the Conference which have been adopted by the Governments affected include the establishment of a Caribbean tourist committee, a meeting of meteorological experts in 1949 which led to improvements in the system of warning against hurricanes, and the grant to the Caribbean area by the University of Puerto Rico of thirty scholarships to its School of Industrial Arts.

German Leather Industries during 1939–45

IN a comprehensive survey of "The Leather Manufacturing and Related Industries in Germany during the Period 1939–1945" (B.I.O.S. Surveys Report No. 27; London: H.M. Stationery Office, 1950; 3*s*. 6*d*. net), Dr. C. H. Spiers has gathered together much valuable information from the reports of the various missions which investigated the German leather industries. These reports do not disclose anything revolutionary as regards actual hide and skin processes, but they show some interesting chemical developments, notably the introduction of two fundamentally new tanning reactions ('immergan' and di-isocyanate tannages), an improved iron tannage ('ferrigan' tannage), the large-scale exploitation of the synthetic tannins, and the production of effective substitutes for natural oils and

fats (derminols). A second sphere of development was in connexion with leather substitutes such as 'lefas', in which leather fibres are bound together by resin emulsions, or plastic soling materials made from polyvinyl chloride ('P'-soles). The production of sausage casings, artificial fibre and surgical sutures from skin pieces by the Naturin-Werk represents a remarkable piece of chemical engineering. An important factor in the progress of the German leather industries has been the benefit which they have received from research and development in the German chemical industry, which systematically seeks new uses for the great variety of materials, intermediates, by-products and waste products which it produces. The high standard of technical management in the leather industry secures that these developments are absorbed and applied by the industry.

The Wellcome Research Library

THE Wellcome Foundation has given £80,000 to the Royal Society of Medicine in order to enlarge the accommodation of the Library of the Society, and to provide endowment for the purchase of books and periodicals from such of the capital of the gift as is not expended on the structural alterations and the equipment necessary to the enlargement. The extension of the present Library is to be named 'The Wellcome Research Library' and it is left to the representatives of the Royal Society of Medicine in collaboration with the Wellcome Trustees to work out an application of the gift which shall preserve the conditions of the Trust and give the maximum effective benefit to the work of the Library of the Royal Society of Medicine. This problem will clearly resolve itself into details of how best to provide the accommodation both for more readers in the Library as well as for the books, while increasing the efficiency of the extensive and complex library service of the Society, without impairing the working of the many other activities of the Society conducted in the building. Enlargement of the House will be necessary, and the Trustees envisaged this in making the gift. Plans have been prepared and are now under consideration.

Adventure in Engineering

'COMMEMORATION DAY' at the Imperial College of Science and Technology, London, was observed on October 27. After an inter-denominational service at Holy Trinity Church, Prince Consort Road, the chairman of the governing body, Viscount Falmouth, the rector, Sir Roderic Hill, the deans, staff and students proceeded to the Great Hall of the Imperial Institute for the ceremony of presentation of diplomates. Following the reception of the new diplomates of the Imperial College, and those of the Royal College of Science, the Royal School of Mines, and the City and Guilds of London Institute, and the presentation of scrolls to the honorary fellows elected during the past year, the 'distinguished visitor', Sir Bruce White, addressed the gathering. Referring to his student days at the City and Guilds College, then known as the Central Technical College, Sir Bruce commented on the great improvement in facilities and equipment that had meantime been achieved. However, despite wider and more intense studies, it seemed to him that engineers of the older generation would leave a deeper mark on the world than would those of to-day; they had vision and initiative which they did not fear to use. Nowadays the incursion of politics into engineering is leading to domination by committees, so that whereas the successful discharge of responsibilities should be the highest aim of all engineers, initiative is in fact being curbed, and responsibility of the individual is escaped or denied. Such a policy contributes to the astronomical cost of some public works to-day. Sir Bruce White advised engineering students to dismiss from their minds the 'safety first' attitude, to scorn to achieve success by an excessive margin of safety, and readily to accept an opportunity of gaining experience abroad. Experience should be sought in many fields of engineering practice, and to that end they should, while still young, be ready to move freely from one employment to another. Life is ambition, and security should not be sought at an early age; ambition kept always before them would in due time find its outlet and fulfilment. In the evening the laboratories and libraries of the Royal College of Science were open to visitors who, with the aid of senior students, were able to inspect and discuss the application of installations, instruments, and apparatus in current use in the teaching and research laboratories of the College.

Ophiuroidea of the Hawaiian Islands

BULLETIN 195 of the Bernice P. Bishop Museum, Honolulu ("Ophiuroidea of the Hawaiian Islands"; pp. 133; 1949), in which Austin H. Clark describes new ophiuroid fauna, is the final report on the echinoderms collected by the United States Fisheries steamer *Albatross* in 1902 and makes a valuable addition to the knowledge of Pacific ophiuroids. Besides the purely systematic description of Hawaiian ophiuroids, which includes the diagnoses of a number of new species, there is an interesting appendix on the general echinoderm fauna of the Hawaiian Islands. In this the writer has analysed the shore catches from different islands as well as the offshore catches, which are recorded under station numbers. The echinoderm fauna of the Hawaiian Islands lies on the periphery of the Indo-Pacific region, and some of the component echinoderms have become modified to form separate species. Although the fauna shows a Japanese element, especially among the sea urchins, brittle-stars and crinoids, the writer points out that this does not constitute evidence pointing to a direct past faunal connexion between southern Japan and the Hawaiian area; the species common to these two regions may, in fact, have reached them by separate routes from the Indo-Pacific faunal centre.

Contributions to Embryology

VOL. 33 of "Contributions to Embryology" maintains the very high standard which always characterizes this journal ("Contributions to Embryology", **33**, Nos. 213–221, Publication 583. Pp. iii+186+34 plates. Washington, D.C.: Carnegie Institution, 1949. 8.50 dollars). It comprises a series of papers on the reproductive organs; a series on embryology; and one anatomical paper by Adolph H. Schultz on "The Palatine Ridges of Primates". The series on reproduction includes a monograph by S. R. M. Reynolds on the changes which occur in the uterine vessels of pregnant rabbits; a paper by Elizabeth M. Ramsey on the vessels of the endometrium in the pregnant rhesus monkey; and a short paper by S. H. Sturgis on the rate of follicular atresia in the ovaries of the rhesus monkey. The most striking of the embryological

papers is a monograph by Hertig and Rock on early human embryos. In recent years these two authors have added almost as much to our knowledge of the earliest stages of man's development as have all previous workers put together. Their present study deals with two human ova of the pre-villous stage, and whose ages are estimated to be about eight and nine days respectively. Like their previous observations, this new study is bound to become text-book material. Finally, the volume contains a review of the histogenesis of cartilage and bone, by the late Dr. George L. Streeter, formerly head of the Department of Embryology, Carnegie Institution of Washington, Baltimore, and to whose inspiration we largely owe the high standard of the journal in which this posthumous paper appears.

Electricity as an Aid to Productivity

A CONFERENCE on "Electricity as an Aid to Productivity", organised by the Institution of Electrical Engineers, will be held in the Lecture Theatre of the Institution during November 15–16. The conference is intended mainly for executives in both large and small factories who are responsible for production, including managers, production engineers and factory engineers, and will consist of a series of lectures on the following five topics: motive power in the factory; industrial heating processes; welding applications; the handling and inspection of materials; lighting, heating, ventilation, etc. The lectures have been planned from the point of view of the user, and will deal, in general terms, with what electricity can do to increase production rather than with technical details. A report of the proceedings of the conference will be published later (price 6*s*.). Tickets for the conference can be obtained from the Secretary of the Institution of Electrical Engineers, Savoy Place, London, W.C.2.

Australian Journal of Applied Science

THE first issue of a new quarterly journal, the *Australian Journal of Applied Science*, published by the Commonwealth Scientific and Industrial Research Organisation, appeared in March 1950 (1, No. 1; pp. 132; Melbourne: Government Printer; 30*s*. a year). It is intended as a medium for the publication of the results of original investigations in the broad field of applied science and is complementary to the *Australian Journal of Scientific Research* (A, Physical; B, Biological), *of Agriculture Research*, and *of Marine and Freshwater Research*, all three of which are published by the same Organisation. The first number covers a wide field with ramifications into electrical technology, applied physics and chemistry, and the technology of timber. There is a detailed study of the setting of synthetic resin and casein glues by means of the viscometer; very full data concerning the mechanical properties of red tulip oak, a tree abundant in Queensland; and an assessment of the value of various tannins, that can be extracted from Australian trees, for the production of adhesives by condensation with formaldehyde. There is also an interesting account of the production of metal surfaces suitable for use as standards of roughness or surface finish; strips of chromium controlled in width, spacing and height are electrolytically deposited on the lapped surface of a steel block. Improvements in the production of graticules by the use of metal films evaporated on to the glass surface are also described, and there is a series of five papers on the special treatments that must be applied to electrical equipment to prevent its rapid deterioration under tropical conditions. These papers record a long series of investigations in which many organisations collaborated during the years 1943–46, and the most vital parts of the information are therefore already known to the radio industry. It is, however, very useful to have a systematic and detailed survey easily accessible for reference. Those who are interested in the physics and chemistry of water-repellent materials for the treatment of glass and ceramic insulators will find much new information in studies of the efficacy of quaternary ammonium as well as organo-silicon compounds used for this purpose. The new *Journal* will be welcomed as an important contribution to the literature of applied science.

Progress in Theoretical Physics

ONE of the most remarkable things that came to light after the end of hostilities in 1945 was the emergence during the War of a vital and important school of theoretical physics in Japan. It is so active that it has been able to found a journal devoted almost exclusively to theoretical physics, which must take its place on the shelves of any complete scientific library, side by side with other important learned journals. *Progress in Theoretical Physics* (published by Akitaya Co., Ltd., Osaka, Kyoto, Japan) is edited by H. Yukawa and printed in English. It started publication in June 1946; but unfortunately it has not, up to the present, been easy to obtain copies in Great Britain. The difficulties seem to be connected with export restrictions imposed by the occupying Powers. It is to be hoped that so important a journal will soon be readily available, and that an adequate stock of back numbers is in existence. The journal is mostly devoted to papers on the quantum theory of fields—as is natural in a country where physics is strongly influenced by the work of Yukawa and Tomonaga—but there are also papers on ferromagnetism and astrophysics in the early issues. It contains many important papers; Tomonaga's classic paper on the covariant formulation of quantum field theories, for example, appeared in the second issue (August–September 1946), to be followed by developments of the idea in later papers. The journal advertises itself on the inside cover as mainly concerned with papers on theoretical physics, which are related to quantum mechanics, statistical mechanics, the theory of relativity and the theory of elementary particles—showing that its editorial board is keenly aware of the direction in which vital advances are being made in physics. Experimental papers intimately connected with contemporary theoretical physics are also eligible for inclusion.

Educational Times

THE *Educational Times*, which was first published in 1847, is now to become a digest of current educational literature and will be published three times a year, in February, June and October (from the College of Preceptors, 2 and 3 Bloomsbury Square, London, W.C.1. 1*s*.). This change has been brought about because it is felt that, with the present-day spate of periodicals dealing wholly or partly with educational topics, the difficulty of the teacher and interested layman is not that he has too little to read, but rather that he has too much and that it is so widely dispersed. It is hoped, therefore, that the *Educational Times* in a new form, and with a new purpose, may satisfy the need of those who wish

be in touch with current educational thought by providing them with summaries of articles and correspondence of outstanding educational interest which have appeared during preceding months in journals of English-speaking countries. The first number (dated October 28) has been prepared by the dean of the College of Preceptors, Mr. J. H. Simpson, and by the secretary of the College, Mr. J. V. Chapman. Subsequent issues will be edited by Mr. Simpson with the assistance of Mr. John Bosworth, a member of the College Council and a master at the Ashburton Secondary Modern School, Croydon.

United Nations Documents Index

THE first issue, dated January 1950, has been published of the *United Nations Documents Index: United Nations and Specialized Agencies Documents and Publications* (1, No. 1, January 1950; pp. 83; Lake Success, N.Y.: United Nations; London: H.M. Stationery Office; 7.50 dollars or 50*s*. a year). This is a monthly publication and is intended to list and index by subjects all such material received by the United Nations Library, except restricted (confidential) material and internal papers. Each issue will contain: introductory material concerning sales, distribution and other pertinent items; a list of documents and publications of the United Nations arranged by symbol, followed by lists for each of the specialized agencies; and a subject index, which will be circulated annually. The publication should become a useful work of reference for librarians, bibliographers and others.

Beckenham and Penge Grammar School: Scientific Society *Proceedings*

STILL further evidence of the growing interest in publishing scientific work carried out in schools has reached us in the above journal. This is the second annual issue; the first was published in 1949 (price 1*s*.). It is of interest to note that this School is a maintained grammar school attended by day pupils, and the papers published in the *Proceedings* record the work done by the boys out of their normal school hours. F. Weiss has been carrying out practical experiments investigating the inheritance of coat-colour in mice, and he records his results in two papers. D. J. Claringbull contributes a useful article on rearing butterflies, incorporating the results of his own activities. Valuable training in team work is exemplified in the survey of a wood at Downe, Kent. Here are recorded observations on the geological formation and nature of the soil (profile, analysis and temperature gradient), a tree census and a plant ecological survey. The team was under the supervision of Mr. F. H. Brightman, and included the following boys: R. J. McB. Allan, M. D. Bass, C. Blyton, B. G. Bowes, P. G. Brand, G. Doughty, P. George, D. R. Hills and A. P. Hughes. Other papers published in this number are: "Radish Fruits: Variation in Length and Seed Number" by B. Davis, D. Holland and R. Marriott; "A Model Gasworks" by A. Chedzoy (the model set up by the author and K. Felton and P. Franks under the supervision of Mr. A. Thorne); "Sunspots" by N. R. B. Hayes, B. T. Henry, D. J. Turner and G. A. Doughty; "A Wind Deflection Model" by M. R. Fry; "Meteorological Records" by M. D. Bass. This journal is most praiseworthy, and reflects keenness and a true appreciation of scientific method and purpose at Beckenham and Penge Grammar School.

Agricultural Research Council: Awards for 1950

THE Agricultural Research Council has announced the following awards for 1950. Junior agricultural research fellowships: Dr. C. Klatzkin (Department of Biochemistry, University College, London), for studies of changes in amino-acid contents of seeds during germination; and Dr. H. Ruben (Department of Genetics, University of Cambridge), for studies in the theory of genetics experimentation. Research studentships and training grants: *Botany Group*, J. L. Jinks, A. D. Kanarek, D. J. C. Friend, N. R. Lee, R. E. Parker, J. McLeish, J. S. Cole, R. A. Lelliott and M. J. Dorey; *Entomology Group*, D. R. Ragge, C. F. Eastop, R. D. Winslow, Miss P. M. Harlow, B. A. Jones and Miss D. Wedlake; *Chemistry Group*, P. H. T. Beckett, R. F. W. Goodwin, L. D. Finch, C. Morgan, J. H. Fessler, D. B. Lindsay, Miss S. M. Wilson, G. P. Askew and D. C. Findlay; *Zoology Group*, K. F. Hosie, B. Shaffer, Miss E. Billing, J. Bligh, M. G. Stokes, P. N. Wilson, K. C. Kirkham, M. E. Lancaster and A. Durrant; *Veterinary Group*, J. Thomas and A. J. S. Campbell.

Faraday Society

SIR CHARLES GOODEVE has been elected president of the Faraday Society in succession to Sir John Lennard-Jones. Sir Alfred Egerton and Prof. H. W. Melville have been elected vice-presidents in succession to the two retiring vice-presidents, Mr. R. P. Bell and Sir Cyril Hinshelwood. Profs. C. H. Desch, F. G. Donnan, Allan Ferguson and M. W. Travers have been elected honorary life members of the Society, a new class of membership recently instituted to honour those of its members who have rendered outstanding services to the Society and to physical chemistry.

Mineralogical Society: Officers and Council, 1950–51

OFFICERS and Council for 1950–51 of the Mineralogical Society have been elected as follows: *President*, Prof. C. E. Tilley; *Vice-Presidents*, Dr. A. F. Hallimond and Dr. S. J. Chand; *Treasurer*, E. H. Beard; *General Secretary*, Dr. G. F. Claringbull; *Foreign Secretary*, Dr. L. J. Spencer; *Editor of the Journal*, Dr. L. J. Spencer; *Ordinary Members of the Council*, Dr. S. O. Agrell, H. G. Dines, G. S. Gowing, Dr. S. I. Tomkeieff, Dr. F. A. Bannister, Dr. J. Phemister, H. M. Powell, H. P. Rooksby, G. E. Howling, P. A. Sabine, Dr. F. H. Stewart and Dr. A. K. Wells.

Announcements

A COLLOQUIUM on sensitive emulsions and their physical and physico-chemical properties will be held in Paris during September 24–29, 1951. The principal topics to be discussed are: physico-chemical properties of the halogen compounds of silver; sensitivity of emulsions and optical sensitization; development; and emulsions for nuclear work. Papers for the colloquium should be submitted before June 1. Further details may be obtained from Mme. A. T. Vassy, Faculté des Sciences de Paris, 1 rue Victor Cousin, Paris 5e.

MR. FRANK GAYNOR has directed attention to an error in the review of his book, "A Pocket Encyclopedia of Atomic Energy", which appeared in *Nature* of August 26, p. 326. It is there stated that Mr. Gaynor does not mention the well-known table of isotopes by Seaborg and Perlman, whereas in fact a reference to this paper appears in the text on page 81. This reference was overlooked by the reviewer, who regrets the omission.

CYTOLOGY, GENETICS AND CLASSIFICATION

An all-day discussion on September 4 on "Cytology and Genetics in Relation to the Classification of Plants and Animals" was arranged by Sections D (Zoology) and K (Botany) of the British Association during the Birmingham meeting. The morning session dealt mainly with animal organisms and the afternoon session with plants.

Mr. S. Muldal (John Innes Horticultural Institution) opened the morning discussion with a general paper on earthworm cytology. The British earthworm fauna comprises the genera *Allolobophora* (five species), *Lumbricus* (five), *Eisenia* (three), *Eiseniella* (one), *Dendrobæna* (four), *Bimastus* (four), *Octolasium* (two) and *Eophila* (one). There are generic differences with regard to cocoon production by unmated worms, there being species with no cocoon production (*Allolobophora*), infertile only (*Lumbricus*), and fertile cocoons (in most other genera). It appears that the mode of reproduction varies from the strictly cross-breeding species such as the British *Allolobophora* and *Lumbricus* species to the obligate parthenogenetic *Octolasium cyaneum* (8*x*), *Eiseniella tetrædra* (4*x*), *Eisenia rosea* (3*x*) and *Bimastus tenuis* (3*x*). The chromosome number is constant in *Lumbricus*, $n = 18$, which is probably the primitive basic number for the family. In *Allolobophora* there are two basic numbers, 18 and 16. In *Dendrobæna* the basic number is 17, in *Bimastus* 16, in *Octolasium* 19, in *Eisenia* 11 and 18, and the subspecies examined of *Eiseniella tetrædra* have $2n = 72$, with 18 as probable basic number. The latter have probably developed from the polymorphic *Eisenia venata*.

All the polyploid worms show obligate parthenogenesis. They are highly successful species, peregrine and cosmopolitan, and exhibit less variation than do the sexual species. It is a general belief, Mr. Muldal said, that polyploidy is very rare in the animal kingdom, but at the moment we have little evidence on which to base this assumption. Large groups of animals are still not examined, and the numbers included in the chromosome lists are often from widely separated species. Only by working through relatively young animal families, like the Lumbricidæ, can one assess the part played by polyploidization in speciation. Old polyploidy, from a phylogenetic point of view, is, however, often impossible to discover in our present animals, since older types with lower multiples may be altogether extinct.

Dr. B. N. Singh (Rothamsted Experimental Station) has studied nuclear division in small free-living amœbæ and its bearing on their classification. The free-living amœbæ have previously been classified largely on the basis of nuclear structure and mode of division. Extraordinary differences in the behaviour of the nuclear constituents have been claimed, and the consequent confusion has been due to two principal causes: the difficulty of getting the various normal stages of nuclear division, owing to lack of suitable cultural conditions; and the use of Hæmatoxylin or other non-specific dyes for showing the nuclear structure and behaviour. A detailed study of the effect of varied bacterial food has led to the development of a standard culture method. This enables one to get all the stages of division in young and healthy specimens. The division of twelve strains of amœbæ, consisting of at least nine distinct species, has been studied.

The use of the Feulgen reaction has shown that the resting nucleus of all the species contains Feulgen-positive granules, which give rise to chromosomes during division. The karyosome (nucleolus) does not contain Feulgen-positive chromatin, nor does it give rise to chromatin at any stage. This brings the mode of nuclear division in line with that in higher animals and plants.

According to their mode of division the amœbæ can be arranged in two groups. In one, the karyosome persists throughout division, whereas in the other it disappears. Such a diversity was not apparent in the earlier works.

The next contribution to the discussion was a paper read by Mr. L. Sachs (School of Agriculture, Cambridge) on cytogenetics in relation to the systematics and phylogeny of the Triticinæ.

The Triticinæ (Gramineæ) contains the genera *Aegilops*, *Agropyron*, *Haynaldia*, *Secale* and *Triticum*, with a total of well over a hundred species. In a comparison of the different methods of investigating the systematics and phylogeny the following modes of approach were discussed and illustrated: gross morphology, chromosome number and morphology, chromosome pairing and fertility in interspecific and intergeneric hybrids, chromosome pairing and fertility in colchicine-derived amphidiploids, the genetic behaviour of certain characters, and the attempted artificial synthesis of existing species.

In the analysis of chromosome pairing in hybrids, Mr. Sachs discussed the genome concept, and evidence was presented to show the desirability of revising the accepted genome formula for the tetraploid species *Triticum timopheevi*. In the discussion on interspecific and intergeneric amphidiploids, it was also suggested that, although some of these are morphologically distinct and reproductively isolated new 'species' or even new 'genera', they should not be given new specific or generic names, but rather formulæ in order to show their experimental origin. The methods of comparative genetics were illustrated by the action of interspecific and intergeneric lethals and sublethals associated with a hexaploid species of *Triticum*. Each of the five genera has evolved in its own way, either by instantaneous speciation brought about by polyploidy or the presence of interspecific lethals, or by gradual speciation brought about by accumulation of gene and chromosome changes.

The last speaker was Dr. J. P. Harding (British Museum (Natural History)), who gave a review of the cytology of some Crustacea as an aid to their classification. He said that consideration of the chromosome numbers of copepods indicates that the more primitive members have the highest numbers. The Calanoida is the most primitive sub-order and the haploid number is nearly always 16 or 17, whereas in the other sub-orders it is rarely more than 12 and may be as low as 2. In Cyclopoida also the highest numbers are found in the more primitive species.

Three closely related species, *Cyclops fuscus*, *C. albidus* and *C. distinctus*, occur in Great Britain, often in the same body of water. *C. distinctus* is on the

whole intermediate between the other two both in its morphology and in its ecological preferences, and many workers have considered it to be a hybrid between them. In both *fuscus* and *albidus*, seven bivalents are found in the oocyte, those of *albidus* being distinctly smaller than those of *fuscus*. In *distinctus* the chromosome number is variable, which indicates its hybrid nature. Breeding experiments do not give direct support to this, for the three forms breed true and are completely intersterile. *C. distinctus* seems to be a good species of hybrid origin.

Closely related species of *Cyclops* may have different chromosome numbers. *C. vernalis*, *C. parcus* and *C. brevispinosus* are so similar that most systematists make no attempt to separate them; their haploid numbers are, however, 5, 3 and 2 respectively.

The true nature of breeding systems can in most cases be assessed only by cytological study, and their determination is a decisive step in working out the systematics of a group. The chromosome number is also an additional morphological characteristic of which too little use has been made so far. The discoveries made with the aid of these newer tools will be of great importance in revising the 'old systematics'.

S. MULDAL

THE first speaker at the afternoon session was Prof. T. J. Jenkin, who described his extensive experimental work on the grass genera, *Lolium* and *Festuca*. Two groups of species, all diploid ($2n=14$), can be distinguished in *Lolium*: one, which is self-pollinated, comprises *L. temulentum*, *L. remotum* and *L. loliaceum*; and the other, which is cross-pollinated, *L. perenne*, *L. rigidum* and *L. italicum*. Within each group more or less fertile interspecific hybrids can be made; and viable hybrids can also be made between members of each group. Among factors which may have been responsible for speciation, involuntary human selection for seed size in *L. temulentum*, a weed of cereals, and in *L. remotum*, a weed of flax, was mentioned as an interesting possibility. *Festuca* is a larger and more widely distributed genus, and contains polyploid as well as diploid species; two groups, narrow-leaved forms such as *F. capillata* ($2n=14$), *F. ovina* ($2n=28$) and *F. rubra* ($2n=42$) and broad-leaved forms such as *F. pratensis* ($2n=14$), *F. arundinacea* ($2n=42$) and *F. gigantea* ($2n=42$), can be distinguished. Again, hybridization within each group is possible, though the hybrids are often male-sterile; but the only hybrid linking the two groups directly is *F. rubra* × *F. arundinacea*, which is weak vegetatively and has never flowered. An indirect link is provided through *Lolium perenne* and *L. loliaceum*, both of which have been successfully crossed with both groups of fescues. These experiments, and the cytological investigations which have been made on the hybrids, clearly have an important bearing on the taxonomy and phylogeny of the genera.

Colonel F. C. Stern, who spoke next, gave several examples of the uses of chromosome number and morphology in solving taxonomic problems; he illustrated his remarks by means of excellent maps. First, in the genus *Pæonia*, the European members can be divided into groups, each containing diploid and tetraploid species. Not only do the chromosome numbers here form an invaluable guide to the taxonomist in distinguishing closely allied forms, such as *P. Cambessedesii* (Balearic Is., $2n=10$) and *P. Russi* var. *leiocarpa* (Corsica, $2n=20$), but they also provide a clue to the phylogeny of the group; it is likely that the diploid forms are the isolated relics of preglacial populations, and that the tetraploids, with their wider and more continuous distribution, have developed in inter- and post-glacial times. Secondly, in *Primula* section *Farinosæ*, subsection Eu-farinosæ, chromosome counts facilitate the distinction of species otherwise almost indistinguishable morphologically, such as *P. scotica* ($2n=54$) and *P. scandinavica* ($2n=72$), and also give an illuminating guide to the relationships of the many polyploid species. The possibility that the circumpolar *P. stricta*, with 126 chromosomes, is an allopolyploid derived from species with 54 and 72 chromosomes, was mentioned. Thirdly, the chromosome number and morphology of the genera *Galanthus* and *Leucojum* were discussed; in *Leucojum* the basic numbers $n=7$, 8, 9 and 11 are known and most of the species are found at the western end of the Mediterranean. In *Galanthus*, practically all the species have $n=12$, and most of the species are found at the eastern end of the Mediterranean and in the Caucasus. It was suggested that the two genera had both been derived from an ancestral European stock that had been split into two parts as a result of glaciation; in this connexion, the close resemblance between *Leucojum vernum* ($n=11$) and species of *Galanthus* was pointed out. It was also shown that breakage or fusion of chromosomes, as in *Fritillaria*, may have been an important factor in species-formation in *Leucojum*. Finally, examples were given of the use of cytology in tracing phylogenetic lines (in *Crepis*) and in deciding between alternative taxonomic arrangements (*Yucca* and *Agave*).

The correlation between morphology, chromosome number and geographical distribution was further developed in the next paper, by Dr. E. K. Janaki-Ammal, on polyploidy in the genus *Rhododendron*. After referring to the early work of Sax, who had suggested that this genus consisted mainly of diploids, with $2n=26$, Dr. Janaki-Ammal described her own recent investigations, which have covered the forty-three sections into which Hutchinson has divided the eight hundred species of the genus. The cytological results can conveniently be summarized under three main groups. First, the *Azalea* group, with a wide distribution in the northern hemisphere, is diploid except for two tetraploid species in North America. Secondly, the non-lepidote group, comprising among others the well-known tree rhododendrons of our gardens, is exclusively diploid; 146 species of this group, which is found mainly in Eastern Asia, have been examined. Thirdly, the lepidote group, composed mainly of montane Himalayan species, contains a very high proportion of polyploids, with chromosome numbers ranging from 52 to 156. The interesting point was made that the circumpolar *R. lapponicum* is always diploid, while its Himalayan relatives are polyploid. These new observations will obviously contribute very greatly to our understanding of the genus *Rhododendron*.

In the fourth paper, Prof. D. H. Valentine spoke about the use of interspecific compatibility as a taxonomic criterion. He began by defining the 'comparium', which is a group composed of all those species which can be united, directly or indirectly, by hybridization; this unit, which was first proposed

by Danser in 1929, is useful because it can be fairly precisely defined[2] and is of a size comparable with the genus or subgenus. In *Primula* section *Vernales*, in *Epilobium* section *Chamænerion*, in *Viola* sections *Nomimium*, *Dischidium*, *Chamæmelanium* and *Melanium*, and in *Pæonia*, sections *Moutan* and *Paon*, the comparium agrees well with the subgenus, section or subsection, and, where it disagrees, it provides useful suggestions for taxonomic revision. On the other hand, it is useless in genera such as *Lathyrus*, in which attempts to obtain interspecific hybrids have failed. It is interesting to note that in some families, for example, the Gramineæ, a single comparium may comprise many genera, such as *Lolium–Festuca*, and *Triticum–Aegilops–Agropyron–Secale–Elymus*.

In order to analyse relationships within or between comparia, it was suggested that variation in what may be called seed compatibility, that is, the ability to form hybrid embryo, seed and seedling, could be used. Examples were given from the genus *Viola* at the sectional-level, and from *Primula*, section *Vernales*, at the specific-level. In the latter, evidence from both seed compatibility and hybrid fertility agrees in placing *P. elatior* closer to *P. vulgaris* than to *P. veris*. Application of this criterion to outbreeding diploid groups (gradual ecospecies) similar to the *Vernales*, for example, portions of the genera *Rhododendron*, *Lolium*, *Quercus* and *Epilobium*, were suggested. It was pointed out, however, that the hypothesis on which this application is based, namely, that degree of seed compatibility is proportional to taxonomic relationship, is clearly incorrect where the relation between diploid and tetraploid species is concerned. Here, analysis shows that comparable pairs of closely allied diploid and tetraploid species may vary enormously in seed compatibility. Thus, they may be completely intercompatible, as in *Viola riviniana* ($n=20$) × *V. reichenbachiana* ($n=10$), completely incompatible, as in *Galeopsis tetrahit* ($n=16$) × *G. speciosa* ($n=8$) or, most commonly, as in *Nasturtium microphyllum* ($n=32$) × *N. officinale* ($n=16$), partially compatible.

In the general discussion which followed, Prof. Jenkin described some interesting results on seed compatibility in *Lolium*, and Dr. Turrill briefly reported some unpublished work of Mr. E. M. Marsden-Jones on *Anagallis*. The numerous colour forms of *A. arvensis* are all intercompatible and interfertile, but only a single one, out of more than thirty that are known, can be crossed with the related species *A. femina*. The reasons for this remarkable limitation of compatibility are as yet unknown.

D. H. Valentine

CHEMISTRY OF THE CELL AND ITS NUCLEUS

A DISCUSSION on "The Chemistry of the Cell with Special Reference to the Nucleus", arranged by Section K (Botany) of the British Association at the Birmingham meeting, took place before a large audience on September 1 under the chairmanship of Prof. K. Mather.

Prof. M. Stacey (University of Birmingham) opened the discussion with a paper on the chemical composition of some cell nucleoproteins. He dealt first with the chemistry of deoxypentose nucleic acids and pentosenucleic acids, indicating that these must now be regarded as two distinct groups of nucleic acid, with quite marked differences in physical and chemical structures between products from different cells. Although the deoxypentose type is found mainly in nucleal structures and the pentose type mainly in cytoplasmic material, it is becoming evident that at different stages of cell-growth—especially in bacteria—there is a good deal of overlap in the location of the two groups of nucleic acid. The nucleic acids are found in firm combination with various types of protein, and methods for their separation were outlined. The basic proteins in chromosomes are more complex than was thought by earlier investigators. The present position was then outlined of the magnesium ribonucleoprotein which forms the dye-retaining part of the surface structure of Gram-positive micro-organisms, and the new observation was made that only a small part of the ribonucleic acid of various cells is bound in the Gram complex. The behaviour of the nucleal proteins under the influence of cell 'autolytic' enzymes, especially the nucleases, was also discussed.

Dr. W. G. Overend dealt with work at Birmingham on the fundamental chemistry of the Feulgen and Dische reactions for cell nucleal material. He explained the need for knowing what takes place during cytological staining practice, particularly in regard to the nucleal components. The Dische reaction is primarily concerned with the deoxyribose in the chromosome nucleic acid, and it is seen as a blue stain when diphenylamine is added to the cellular material previously treated briefly with acetic and sulphuric acids. Studies on a wide variety of unusual carbohydrates, using spectrographic techniques, show that it is given by 2-deoxy pentoses and by furfuryl alcohol. These under acid conditions are finally converted into lævulic acid, which gives no colour with the reagent. It was shown that an intermediate substance in the conversion, namely, ω-hydroxy-lævulic aldehyde, is the actual compound giving the dye with diphenylamine. Other compounds such as deoxyxyloses, which can be converted into this aldehyde, can give the Dische diphenylamine reaction, which is therefore relatively non-specific, and caution must be used in interpreting the results of the test. Protein breakdown products also influence the amount of colour produced.

The Feulgen reaction, which has been so valuable in locating nucleal structures, consists in the action of Schiff's aldehyde reagent on acid-treated cells to give a magenta colour. It depends on the fact that in deoxypentosenucleic acid the deoxy sugar occurs in the furanose or 5-atom ring form, and under acid conditions the ring opens readily to give a relatively high proportion of the open-chain form, which gives the aldehyde reaction. Model substances having different ring forms of different normal and deoxy sugars illustrate this point. In cells the aldehydo sugar is still attached to the purine and pyrimidine bases in the nucleoprotein, and the complex dye is therefore non-diffusible and locates precisely the nucleic acids. It was clear from Dr. Overend's remarks, however, how the action of lytic enzymes or over-hydrolysis by acids can give discrepancies in application of the reaction.

Mr. F. L. La Cour next discussed some aspects of his work at the John Innes Horticultural Institution on heterochromatin in plants. He explained briefly that the term 'heterochromatin' has been used to

define specific chromosome segments which remain heavily stained and condensed at certain phases of the nucleal cycle. Heterochromatin is attached to the histone type of protein, whereas euchromatin is attached to more basic proteins. The amount of heterochromatin at various stages probably depends on competition with the euchromatin. The heterochromatin can be made particularly visible at metaphase by working at relatively low temperatures, for example, at +5°, especially in cells from root tips. Using the method of working 'in the cold', Mr. La Cour has obtained a variety of results which he showed by micrographs and by numerous striking diagrams. In some plant species the chromosome segments are well defined, whereas in others they are either absent or the genes composing them are too minute to show up. Significant results have been obtained with various species of *Fritillaria* obtained from both the New and the Old Worlds. In some of the New World species heterochromatin is absent. The heterochromatin maps clearly enable one to detect species and give information on hybridity. Heterochromatin is probably concerned with the transfer of gene products to the cytoplasm.

In the final paper of the session, Mr. I. Leslie described recent work of the Biochemistry Department of the University of Glasgow on the role of the cell nucleus in the biochemistry of tissue growth. Based on Vendrely's postulate that the nucleus is a constant chemical entity in the cell, Mr. Leslie and his colleagues selected deoxyribonucleic acid as a constant measurable component (by phosphorus analysis) of the nucleus and are able to express results as increases in actual cell number and as variations in amounts per cell of the other cell components. This method gives a new and easily applied method of measuring growth, which is superior to methods based on measurement of changes of concentration per unit we ght.

The deoxyribonucleic acid content per nucleus varies with the pathological conditions; for example, in fowl sarcoma the unit is 2·8 instead of the normal 1·4. Special applications of the analytical technique were then described. With the roller-tube tissue-culture methods under aseptic conditions, it is possible to measure the changes in number of cells with time up to a maximum in a period of 96 hr. and to correlate these figures with increases in protein, phospholipid components, etc. Between 0 and 48 hr. the proteins and phospholipids increase most rapidly and are synthesized mainly before the deoxyribonucleic acid, and before cell division occurs. On the other hand, the ribonucleic acid content was shown to be greatest during cell multiplication. Some clearly marked changes are seen in the developing chick embryo, the most striking being the remarkable increase in muscle protein and acid-soluble phosphorus at the eighteenth day—presumably for the chick's purpose of extricating itself from the shell. Medical aspects in health and disease were then described, notably concerning glucuronidase in rat liver and for following changes in bone marrow components and in leukæmia and pernicious anæmia.

In the latter disease, there is a markedly higher content of deoxyribonucleic acid when double sets of chromosomes are seen and later the cells fail to divide. In chemically induced tumours and other abnormal growth cells, the failure to synthesize proteins can be seen in a clear fashion.

M. STACEY

VIBRATIONAL STUDY OF THE WOOD USED FOR THE SOUND BOARDS OF PIANOS

By EIICHI FUKADA

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I HAVE measured the dynamic Young's modulus and the logarithmic decrement of spruce (in Japanese, *Kuroezomatsu*) which is used for the sound board of the piano; and I have investigated the difference in these physical quantities between suitable woods for sound boards and unsuitable ones, as chosen by the piano maker by experience.

The method of experiment[1] was the lateral vibration of a plate about 30 cm. long, 2 cm. wide and 0·3 cm. thick. The Young's moduli were determined from the resonant frequencies of this sample. The logarithmic decrements were determined by measuring the total charge of the rectified damped electric current which was caused in the pick-up by the damped oscillation of the sample.

Suitable materials had widths of annual rings of about 1–2 mm.; unsuitable materials had rather large annual rings (about 3 mm.). Two or three pieces of so-called red wood and rotted wood respectively were used. The fibres were orientated in the direction of length of the plate. Discrimination was easy by observing the appearance. The red wood is usually found in the lower part of the tree trunk. It is rather red coloured, hard and readily distorted. Rotted wood is wood which has begun to decompose.

Some of my results are shown in the accompanying graphs. Summarizing, I conclude that Young's modulus is higher for the suitable wood than for the unsuitable material, and that the logarithmic decre-

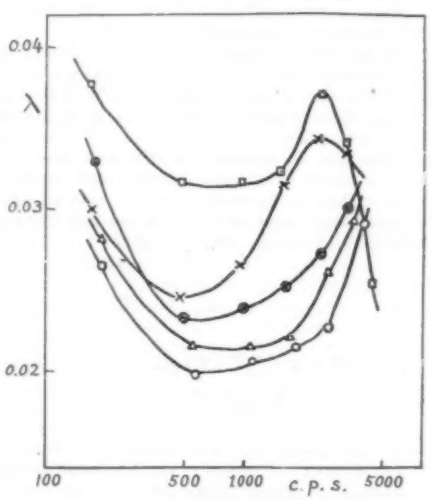

Fig. 1. Comparison of logarithmic decrement of suitable and unsuitable woods

○, 2-mm. annual ring; $E = 1{\cdot}22 \times 10^{11}$ dynes/cm.²
△, 1-mm. annual ring; $E = 1{\cdot}18 \times 10^{11}$ dynes/cm.²
⊕, larger width of annual ring; $E = 1{\cdot}20 \times 10^{11}$ dynes/cm.²
×, rotted wood; $E = 0{\cdot}8 \times 10^{11}$ dynes/cm.²
□, red wood; $E = 1{\cdot}0 \times 10^{11}$ dynes/cm.²

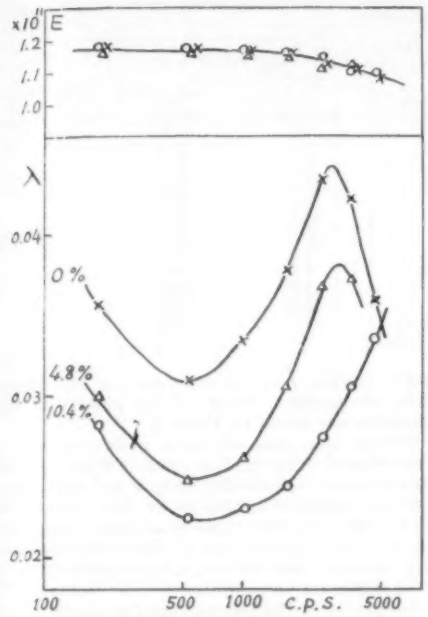

Fig. 2. Effect of moisture content

ment is smaller for the suitable material and larger for the unsuitable one. The unsuitable material with width of annual ring of about 3 mm. shows the same value of Young's modulus but a little larger decrement compared with the suitable one. In the case of both red wood and rotted wood, the maximum logarithmic decrement was found at a frequency of about 2,000–3,000 c.p.s. Suitable material will probably show such a maximum at the frequency of about 5,000–6,000 c.p.s. These frequency ranges could not be measured with the present apparatus. In any event, suitable wood has the larger Young's modulus and the smaller decrement.

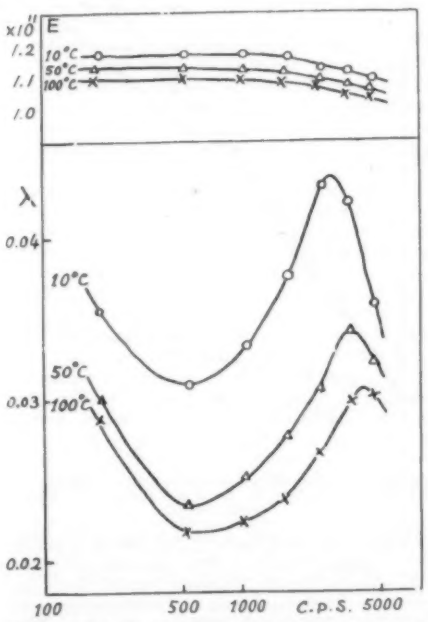

Fig. 3. Effect of temperature in the absolutely dry state

The frequency character of the logarithmic decrement varies considerably with the moisture content and the temperature. One example for a suitable wood is given in Fig. 2. Young's modulus shows no change for moisture contents of 10·4, 4·8 and 0·0 per cent, respectively. The decrement increases as drying and the maximum frequency becomes smaller. In the absolutely dried state the variation due to the temperature of measurement is seen in Fig. 3. Young's modulus decreases with temperature. Decrement also decreases with temperature and the maximum frequency becomes larger. This behaviour of decrement with frequency is very common in many woods other than spruce. It suggests there is some relaxation phenomenon in the structure of wood causing such a maximum decrement. It will be discussed fully elsewhere.

I wish to express my thanks to Dr. Heiji Kawai for his guidance and encouragement throughout this work. [March 28.

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PROTECTION OF ENZYMES BY ANTICHOLINE-OXIDASES AGAINST INACTIVATION BY NITROGEN MUSTARD

By J. S. COLTER* and Prof. J. H. QUASTEL, F.R.S.

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THE nitrogen mustards have excited considerable interest in recent years because of their use as therapeutic agents in Hodgkin's disease, lymphosarcoma and leukæmia[1,2,3,4,5,6]. It is obviously of interest to discover the mode of action of the nitrogen mustards in bringing about their cytotoxic effects, particularly if such investigations would lead to the formulation, or discovery, of substances having greater specificity of action on tumours and less toxic action on the host tissue. One useful line of inquiry is the investigation of the toxic action of nitrogen mustards on enzyme systems, and of the chemical nature of substances that might enhance or inhibit this effect.

In spite of the high degree of reactivity of the nitrogen mustards in aqueous, weakly alkaline solutions, which would lead one to suppose that they would be powerful inhibitors of a large number of enzyme systems, the investigations of numerous workers have demonstrated that this is not the case. Barron, Bartlett and Miller[7] have shown, however, that choline oxidase and the choline acetylase system are strongly inhibited by the nitrogen mustards, and have confirmed the findings of Thompson[8] and of Adams and Thompson[9] that acetyl choline esterase is similarly strongly inhibited by these poisons.

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Table 1. Protection of choline oxidase against the toxic action of nitrogen mustard, by the ferricyanide technique[10,11]. Choline oxidase activity examined anaerobically

Protector molecule (P)	Molar concentration of P	Molar concentration of nitrogen mustard	Incubation time, Min.	Percentage inhibition of choline oxidase		Percentage protection by P against nitrogen mustard
				In presence of P	In absence of P	
Ammonium ion	0·15	10^{-4}	30	63	97	35
Methylamine	0·05	10^{-4}	15	3·8	78·4	95
Methylamine	0·025	10^{-4}	15	16·0	54·5	71
Dimethylamine	0·05	10^{-4}	15	6·9	69·0	90
Ethanolamine	0·05	10^{-4}	15	29·3	73·1	60
Nicotinamide	0·05	10^{-4}	15	39·0	62·0	37
Histamine	0·025	10^{-4}	15	31·0	82·7	62
Tyramine	0·05	10^{-4}	15	3·7	56·6	93
Benzedrine	0·05	10^{-4}	15	6·2	86·7	93
Benzedrine	0·005	10^{-4}	15	5·5	55·8	90
Ephedrine	0·025	10^{-4}	15	17·8	67·0	73
p-Aminobenzoic acid	0·02	10^{-4}	15	56·7	56·3	0
Glycine	0·05	10^{-4}	15	75·6	71·6	0

Barron, Bartlett and Miller[7] have shown that inhibition of choline oxidase by nitrogen mustard can be prevented, or markedly decreased, by the addition of choline to the enzyme previous to, or simultaneously with, the addition of the nitrogen mustard. They have shown further that the addition of thiosulphate previous to addition of nitrogen mustard prevents inhibition—the protection in this case being due to a direct immobilization of the nitrogen mustard by thiosulphate.

The present paper is a preliminary report of work carried out with the object of finding molecules, other than choline, which will prevent, by direct association with the enzyme, the inhibition of choline oxidase by nitrogen mustard. Rat liver homogenate was used throughout as the source of the enzyme, and in all experiments the nitrogen mustard employed was methyl-***bis***-(β-chloroethyl)amine.

Rat liver homogenate (in 0·05 *M* phosphate buffer, *p*H 7·4) was incubated at 37° C. in the presence of the protector molecule for fifteen minutes, at which time methyl-***bis***-(β-chloroethyl)amine was added and the incubation allowed to continue for an additional period of time (usually fifteen minutes). The homogenate suspension was then centrifuged, the supernatant liquid removed, and the solid residue washed twice with saline–phosphate buffer mixture before being suspended in distilled water.

The choline oxidase activity of such a preparation was compared with that of liver homogenate which had been incubated either alone, or in the presence of the 'protector' alone, or in the presence of methyl-***bis***-(β-chloroethyl)amine alone.

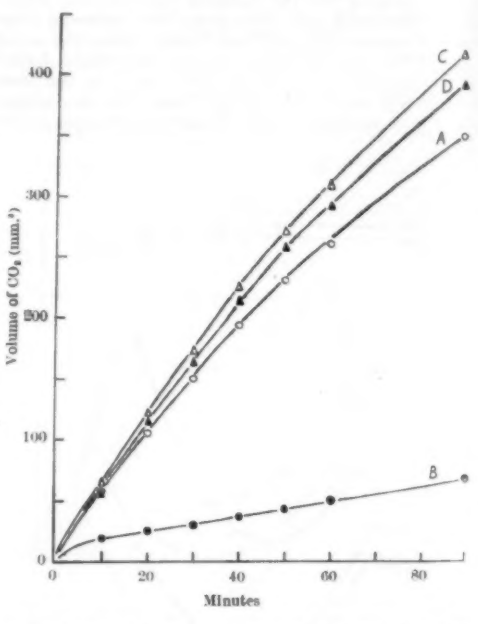
Estimations of choline oxidase activity were carried out both aerobically and anaerobically, employing, in the case of anaerobic oxidation, the method described by Quastel and Wheatley[10] using ferricyanide as the terminal hydrogen acceptor. The choline concentration uniformly employed was 0·01 *M*.

The first 'protector' molecules tested were ammonium ions and methylamine, these being suggested by the observation of Mann, Woodward and Quastel[11] that choline oxidation is inhibited by ammonium ions and by trimethylamine. A preliminary list of the 'protector' molecules tested, and of their effects, is given in Table 1, choline oxidase activity, in all cases, being estimated anaerobically. The graph shows a typical series of curves obtained from one such experiment.

The same molecules which were tested as 'protectors' of choline oxidase were further tested as inhibitors of this enzyme. In this case, estimations of choline oxidase activity were made in the presence of these molecules. Some of the results of these experiments are given in Table 2.

It will be seen that all those molecules that are capable of protecting choline oxidase from inhibition by methyl-***bis***-(β-chloroethyl)amine are also able to inhibit the oxidation of choline by this enzyme. The inhibition produced by these molecules—unlike that produced by methyl-***bis***-(β-chloroethyl)amine—is readily reversed and its magnitude depends on the ratio of substrate to inhibitor.

Examination of the results given in Tables 1 and 2 reveals a close correlation between the efficiencies of



Anaerobic oxidation of choline by rat liver choline oxidase. Gas phase 93% N_2–7% CO_2: 0·025 *M* $NaHCO_3$; 0·01 *M* choline; temp.: 37° C.

A, Choline oxidase activity of rat liver homogenate incubated 30 min. at 37° C.; *B*, Choline oxidase activity of rat liver homogenate incubated 15 min. at 37° C. and with 10^{-4} *M* nitrogen mustard for 15 min.; *C*, Choline oxidase activity of rat liver homogenate incubated 30 min. at 37° C. with 0·05 *M* benzedrine; *D*, Choline oxidase activity of rat liver homogenate incubated 15 min. at 37° C. with 0·05 *M* benzedrine and for 15 min. with 0·05 *M* benzedrine plus 10^{-4} *M* nitrogen mustard

Table 2. Inhibitions by anticholine-oxidases.

Inhibitor	Concentration of inhibitor (*M*)	% Inhibition of choline oxidase. (Concentration of choline = 0·01 *M*)	
		Estimated anaerobically	Estimated aerobically
Methylamine	0·05	44·5	—
	0·025	24·7	21·0
Dimethylamine	0·025	—	32·0
Ethanolamine	0·025	—	16·2
Nicotinamide	0·05	15·3	—
	0·025	—	3·1
Histamine	0·025	52·2	28·0
Tyramine	0·05	100·0	—
	0·025	100·0	100·0
	0·01	100·0	85·3
Benzedrine	0·025	100·0	100·0
	0·01	100·0	—
	0·005	86·2	—
	0·001	—	45·2
	0·0005	—	22·0
Ephedrine	0·025	—	77·6
p-Aminobenzoic acid	0·025	—	2·4
Glycine	0·025	2·0	3·8

those molecules that act as protectors against nitrogen mustard and as direct inhibitors of choline oxidase. The results also show that amino-acids such as glycine and *p*-aminobenzoic acid are inert as protectors or inhibitors of choline oxidase.

The mechanism of the protective action is easily understood on the basis of competitive action between choline and the protector molecule for the enzyme. The phenomenon is strictly analogous to the succinate–malonate competition for succinic dehydrogenase discovered by Quastel and Wooldridge[12]. Presumably the protector molecules become attached to the enzyme at the active centre attacked by the nitrogen mustard, inhibiting the irreversible combination brought about by the latter molecule. Further treatment of the system, by washing, not only removes the uncombined nitrogen mustard, but also reverses the loose combination between enzyme and protector molecule. The activity of the enzyme is thus restored.

Attention may be directed to the highly protective effects exercised by benzedrine (phenyl*iso*propylamine), ephedrine, tyramine, methylamine, dimethylamine and even by such molecules as ethanolamine and histamine, all these molecules acting as competitive inhibitors to choline oxidase. They act, in fact, as anticholine-oxidases and will be referred to by this term. Work is in progress to discover the affinity constants of the anticholine-oxidases both to this enzyme and to other enzymes involving activation of choline (for example, choline esterase and the choline acetylase system).

It will be of distinct interest to discover whether anticholine-oxidases such as benzedrine, etc., which prevent the access of nitrogen mustard to choline oxidase, will also prevent its access to other enzymes and to those structures of the cell involved in the cytotoxic action of nitrogen mustard. It will also be of interest to see whether those anticholine-oxidases that have a high affinity for choline oxidase may also have therapeutic effects, particularly in those diseases favourably affected by nitrogen mustard.

Summary. Benzedrine (phenyl*iso*propylamine), ephedrine, tyramine, methylamine, dimethylamine, ethanolamine and histamine act as competitive anticholine-oxidases. They protect choline oxidase against the inactivating effect of nitrogen mustard.

Grateful acknowledgment must be made of a grant from the National Cancer Institute of Canada in aid of this work.

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ION EXCHANGE

GORDON RESEARCH CONFERENCE

THE aim of the Gordon Research Conferences is not so much to produce completed scientific papers, but rather to provide an exchange of current results in order to bridge the gap between advanced stages of the work and its appearance in print. How necessary this is in a rapidly developing field could be seen from the fact that, in the conference on ion exchange, held in New Hampton, N.H., during July 23–28, certain fundamental investigations on ion-exchangers were reported by no less than five different research groups. These dealt with the swelling and exchange properties of resins of different degree of chain cross-linking; they showed uniformly that the uptake of swelling water and the speed of exchange decreases with increased cross-linking, while at the same time the specificity of the resin for different ions increases. Also, for very high cross-linkage, a very non-ideal behaviour is exhibited by the resins, preference of absorption between two ions changing with the ionic composition of the resin.

The first paper—after an informal introduction by the director of the Conferences, Dr. W. G. Parks—was presented by G. E. Boyd (Oak Ridge National Laboratory, Tennessee). Outlining both the differences and similarities in the thermodynamic approach to partition phenomena such as ion exchange in crystals, in organic exchangers and in surface films, Boyd presented a wide array of experimental results, ranging from the exchange of silver chloride with bromide ion to exchanges of resins of different cross-linking and to the sodium–calcium exchange in stearate films on water. The method of investigation utilized radioactive tracers using gamma-scintillation counters of a high counting accuracy. A novel feature among the many results reported by Boyd was the use of chelating resins, which are highly selective for elements of the transition groups. For some cations the binding is so strong that there is no longer a self-exchange, for example, between copper ions and copper-chelate-resin, although this exchange may be rapid in other cases, like strontium.

E. Glueckauf (Atomic Energy Research Establishment, Harwell), after outlining the current experimental ion-exchange research carried out at the Chemical Research Laboratory, Teddington, and at Harwell, developed a thermodynamic theory of ion-exchange, based on the treatment of the ion-

exchange resin as a strong electrolyte, which, due to the cross-linking of the monomer chains, is subjected to internal forces equivalent to a swelling pressure. By expressing the chemical potentials by means of activity and osmotic coefficients, and utilizing Harned's rule for these coefficients in mixtures of electrolytes, Glueckauf obtained equations which were in satisfactory agreement with experimental results obtained by J. F. Duncan, J. W. Edwards and A. W. Gardner (Harwell), and which lead to the following general conclusions. (*a*) The 'swelling pressure' turns out to be a mildly curved function of the equivalent-volume of the resinate. (*b*) While the swelling-pressure term influences the water-uptake of the resin, it does not affect greatly the electrolyte activity in the resin, which therefore, for resins of moderate cross-linkage, can be expressed almost equally well without considering swelling pressures, but not without considering the activity coefficients in the resin phase. (*c*) Increased cross-linkage should improve discrimination between different ions, and (*d*), for a given resin, ions of equal charge should be the more strongly absorbed the less they swell the resin, which is in agreement with the general body of experimental evidence. (*e*) Mean molal activity coefficients can be assigned to the various metal ion resinates, and in the case of 'Dowex 50' these are approximately half those of the corresponding nitrates. This suggests considerable ion-pair formation in the resinates (see also the later paper by W. Juda).

Following this, H. D. Gregor (Polytechnical Institute, Brooklyn) outlined further developments of his theory, which treats the resin phase as an aqueous swelling electrolyte, but neglects activity coefficients. He also presented an impressive amount of experimental work on swelling phenomena, electrolyte uptake from concentrated aqueous solutions and exchange behaviour of resins of different degrees of cross-linkage, both for inorganic and organic electrolytes, and for cationic and anionic exchangers. Gregor showed that the capacity of an anion-exchanger ('Dowex 2') is effectively independent of the size of the anions, and that the exchange constant for an anion pair $A—B$ is approximately equal to the ratio of the constants for the pairs $A—C$ and $B—C$, which indicates that there can be only little specific interaction between the different anions absorbed in the same resin.

A completely different approach towards the elucidation of the internal structure of cation exchangers was presented by W. Juda (Ionics Inc., Cambridge, Mass.). By studying the electrical conductivity and the transference of sodium ions in a sodium cation-exchanger of varying internal sodium chloride content, and by interpreting these results in terms of the dissociation of the sodium resinate, Juda concluded that the sodium resinate was undissociated to a considerable extent. He also deduced that the Debye-Hückel theory, applied to systems where one ion is held stationary—as in exchange resins—leads to activities which, in dilute solutions, are half those of the ordinary electrolytes. This prediction seems to agree roughly with the activity coefficients calculated by Glueckauf from equilibrium data, though the latter refer to 'concentrated' ion-exchangers.

M. R. J. Wyllie (Gulf Res. and Dev. Co., Pittsburgh) reported some work done by T. R. E. Kressman (Permutit Co., London) on the use of cation exchange resins as diaphragms in concentration cells. These behave 'ideally' for dilute solutions, but, for solutions of 0·5 molar and above, transference numbers fall below unity due to the fact that anions will then take part in the transport of electric charge. Wyllie also reported potential measurements on cells in which clay membranes (by Marshall) are used. These experiments indicate that clay membranes—unlike the organic ion-exchangers—are not porous to water.

Anion exchange experiments through protamine-collodion membranes by K. Sollner (Nat. Inst. of Health, Bethesda, Maryland) were reported by H. Gregor. It was shown that the electrical resistance of collodion membranes after impregnation with the amine increased considerably due to the impermeability of this membrane for cations. The conductance of this membrane is greatly affected by the size of the anions, as the 'pores' are of a diameter comparable to that of the larger anions like sulphate and phosphate.

K. A. Kraus (Oak Ridge National Laboratory, Tennessee) presented new data on the use of anion exchangers for separations involving cations of a valency of three or more, by complexing these with hydrogen chloride, hydrogen fluoride and mixtures of these with concentrated ammonium chloride solutions. He described very effective separations involving the elements niobium, tantalum, protactinium, iron, hafnium, zirconium, rare earths, and others, and discussed the formation of complex anions of these metals, particularly of iron, on the basis of equilibrium constants obtained under conditions of varying concentration of the complexing halides.

Application of ion-exchangers to biological work were discussed by A. Reid (South Western Medical School, Dallas, Texas), with particular reference to the treatment of blood. Thus calcium ions, the presence of which coagulates blood, can be removed, but the storage qualities are adversely affected; neither has the removal of poisons from the blood-stream been successful yet, as apparently vital substances are removed at the same time. G. W. Bodamer (Rohm and Haas Co., Philadelphia) then reviewed ion exchange phenomena in non-aqueous media, including work by Kitchener and Kressman[1].

The catalytic properties of ion exchange substances were discussed by L. P. Hammett (Columbia University) and by F. Nachod (Sterling Winthrop Res. Inst., New York), the chairman of the conference for next year. After stressing the technical advantages deriving from the use of catalysts which can be filtered off after use, Hammett discussed experimental results and their implications. For example, in ester hydrolysis the relative efficiency of acid resins as compared with hydrochloric acid falls off rapidly with increasing mol-volume of the ester, but the process is almost independent of grain size and therefore not controlled by diffusion; the energy of activation is less than the corresponding one for hydrochloric acid, for which fact the proximity of the organic resin-matrix might be responsible.

Dr. W. Rieman (Rutgers University) then discussed the analytical uses of ion exchangers such as removal of interfering elements, separation into two or more constituents, determination of total salt contents, concentration of trace elements and chromatographic separation of similar ions from each other. An experimental test of the theory of chromatography was described by H. C. Thomas (Sterling Chemistry Lab., New Haven), who used a Jones reductor tube running at high percolation speed as the prototype of a chromatographic column suffering from 'film

diffusion' disturbances. Satisfactory agreement between theory and experiment was obtained.

Evaluation methods and characterization of their ion-exchange substances were discussed by R. Kunin (Rohm and Haas Co., Philadelphia), W. Bauman (Dow Chemical Co., Midland, Michigan) and W. Utermohlen (Permutit Co., Birmingham, N.J.). Kunin reported methods for capacity determination, which differ considerably for strong and weak cation and anion exchangers. He reviewed both acid and base exchange constants, and it is of interest to note that, for example, 'IRA 400' is a stronger base than sodium hydroxide and will liberate pure sodium hydroxide solution from sodium salts. He also reported the effects already mentioned of different cross-linking on reaction-rates and on the capacity for large cations, and showed that in the case of anion exchangers, too, increased cross-linking results in increased specificity and that very considerable variation of the separation factor occurs as a function of the mol-ratio of the absorbed ions. Bauman, after discussing the structure of 'Dowex 50', dwelt particularly on the properties of anions exchangers, such as swelling dependence on cross-linking, chemical stability, titration curves, and exchange constants for a large variety of organic and inorganic anions. The last session of the Conference was devoted to a discussion of engineering factors by F. J. Roberts (Dorr Co., Westport, Conn.) and by G. P. Monet (Du Pont Co., Wilmington, Delaware).

The Conference, under the able chairmanship of Dr. R. Kunin, dealt on the average with two papers per session, allowing for a full and free discussion, and this contrasted very favourably with the often very over-crowded discussions of many scientific societies. A feature of the Conference which also deserves recommendation was the arrangement into morning and evening sessions, which left the afternoons free for either private discussions or mental recuperation.

E. GLUECKAUF

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FERROMAGNETISM AND ANTI-FERROMAGNETISM

AN international conference on ferromagnetism and anti-ferromagnetism was held at Grenoble in the first week of July, organised by Prof. L. Néel under the auspices of the Centre National de la Recherche Scientifique with assistance from the Rockefeller Foundation. It was attended by some seventy scientific workers from Europe and America, and a total of about fifty papers were read and discussed in the five days of the conference. In this report it will not be possible to mention all the papers or to give a full account of any of them. References will be given to published papers where these cover more or less the same ground as the reports presented to the conference; the proceedings are to be published in a single volume towards the end of 1950.

The papers on ferromagnetism reflected the great increase in precise knowledge about Weiss domains and their arrangement which has come about in the past few years, and the consequent possibility of more detailed interpretation of magnetization processes. Those on anti-ferromagnetism illustrated the recent revival of interest in non-metallic magnetic materials, the considerable accumulation of empirical facts and the beginnings of their reduction to order by generalizing theories.

The most direct experimental evidence for the size and shape of the domains of a ferromagnetic is obtained by applying a magnetic powder to the surface of the material to reveal the outlines of the domains. This technique was described by Dr. R. M. Bozorth and illustrated by remarkably clear slides of the domain structures observed on various materials[1]. By careful shaping of a single crystal specimen, it is possible to obtain a structure consisting effectively of only two domains, magnetized in opposite directions, with a single boundary wall separating them. Investigations of such specimens were described by Dr. W. Shockley and by Dr. K. H. Stewart, the former showing a film in which the motion of the wall could be followed as the magnetization changed; the way in which small imperfections in the crystal acted as obstacles to the movement of the wall, through the formation of the 'spike domains' predicted theoretically by Néel[2], could be seen clearly. The speed of wall movement in these specimens was found to be controlled by eddy-current effects. In the course of the ensuing discussion, Prof. L. F. Bates showed a very beautiful film of Bitter figures formed on a single crystal of cobalt, which has a particularly simple domain structure; he also showed many pictures of domain boundaries on single crystal surfaces of silicon–iron which provided quantitative proof of the essential correctness of the Néel theory.

The subject of time-effects in changes of magnetization was taken up more generally by Prof. R. Becker, who dealt with the relative importance of eddy currents and of the wall inertia effect predicted by Döring[3]. Prof. Néel outlined a new treatment of time-effects, showing that the concept of an internal field changing slowly with time and hence changing the magnetization gave results of wider application than the concept of the magnetization itself changing with time. He distinguished between 'reversible viscosity', which he attributed to changes in magneto-crystalline anisotropy due to the diffusion of atoms of impurities, and 'irreversible viscosity', due to the effects of thermal fluctuations on the movement of domain walls[4]. Experiments on 'irreversible viscosity' were described by J. C. Barbier[5], and Prof. R. Goldschmidt showed the importance of time-effects in technical applications. The very slow changes in the magnetization of rocks and clays, and the remarkable extent to which they can 'record' past magnetic history, were discussed by Prof. E. Thellier.

Turning from these questions of 'dynamics' to those of 'statics'—the factors controlling the shapes of magnetization curves—the Rayleigh region of the magnetization curve was discussed in the light of Néel's theoretical treatment[6] by Dr. L. Epelboin and by Dr. L. Lliboutry, the latter considering the effects of small mechanical stresses as well as of small magnetic fields. In the region of high fields, Prof. L. Weil described recent theories of coercive force and their experimental verification; Néel's theory of coercive force in continuous ferromagnetic media[7] is not easy to check in any detail; but the theory for ferromagnetics consisting of particles so small as to contain only one domain each (Néel[8], Stoner and Wohlfarth[9]) can be checked in various ways by varying temperature, composition and particle size, and agrees well with experiment. The technical aspects of high-coercivity materials were treated by Dr. K. Hoselitz in a review of progress in the field of permanent magnets.

Although rapid progress has been made in interpreting magnetization processes in terms of domain structure, there have been no great advances in the more fundamental problems of ferromagnetism, those of the interactions between carriers of magnetic moment leading to a finite spontaneous magnetization in the absence of a field. Prof. E. C. Stoner showed how the 'collective electron' approach[10], regarding the carriers of magnetic moment as shared between all the atoms of the lattice rather than attached to individual atoms, could give a general account of the behaviour of ferromagnetics more satisfactory in some respects than those of older theories. Prof. R. Forrer extended his previous interpretation[11] of the saturation moments of alloys in terms of a 'permanent' and a 'supplementary' moment by supposing the latter to be due to an intermittent activation of certain electrons into higher states.

Reports of experimental work on saturation moments and allied questions were given by Prof. W. Sucksmith, who has measured the temperature variation of saturation moment in a cobalt single crystal and in ordered and disordered iron–nickel alloys; Dr. P. Taglang, who has determined the moments of several series of 'iso-electronic' alloys; Dr. A. Meyer, who has found the gyromagnetic ratio for iron, nickel and various alloys to be exactly 2, within the small limits of experimental error; and Prof. L. F. Bates, who outlined the main results of his extensive work on temperature changes during magnetization and showed that they can be related reasonably well to other thermal properties by the thermodynamic theory of Stoner and Rhodes[12].

Anti-ferromagnetism, which, until recently, has received much less attention than ferromagnetism, is a consequence of negative interactions between carriers of magnetic moment, interactions tending to make the moments of neighbouring carriers point in opposite directions. Néel[13] was the first to show that such interactions can lead to just as great ordering of magnetic moments as can the positive interactions characteristic of ferromagnetism, though the resultant magnetic properties are not usually so striking. Recent theoretical developments were outlined at the conference by Prof. J. H. van Vleck. The basic idea is to regard the crystal lattice of the material as made up of two interlocking sub-lattices such that all the neighbours of each atom of one sub-lattice belong to the other sub-lattice; the interaction energy will then be a minimum if all the atomic moments of one sub-lattice point in the same direction, antiparallel to all the moments of the other sub-lattice, and this ordered arrangement will actually occur if the temperature is below a certain critical value, the Curie point. The quantitative theory, using the concept of a 'molecular field' to represent the interactions, predicts a susceptibility rising slowly to a maximum at the Curie point and thereafter decreasing with increasing temperature. Experimental disagreements with the simple theory indicate clearly that interactions between next nearest neighbours are often of even greater importance than those between nearest neighbours, and make it possible to calculate the ratio of the two types of interaction. The importance of next nearest neighbour interaction can reasonably be interpreted if the interaction is not a simple exchange one but an indirect one of 'superexchange' with an oxygen atom playing the part of intermediary, as suggested by Kramers[14] and Néel[15]. Striking evidence for the division into two sub-lattices below the Curie point has recently been provided by neutron diffraction experiments (Shull[16]), showing a periodicity twice as great as the normal lattice spacing.

The experimental study of various anti-ferromagnetic compounds was described by Prof. H. Bizette, Prof. G. Foëx, Dr. F. Trombe, and by Dr. C. Guillaud. Besides determining the Curie temperatures, Prof. Bizette has found the preferred directions of orientation of moments, analogous to the 'easy directions of magnetization', for several crystals.

At very low temperatures many substances exhibit anomalies of specific heat and magnetic behaviour. These were reviewed by Dr. N. Kurti, who showed that further data are required to decide whether the anomalies are evidence of ferromagnetism or of anti-ferromagnetism, and that the ordinary Lorentz dipole interaction field of $\frac{4}{3}\pi I$ is large enough to be of dominating importance in most cases. Similar low-temperature experiments were described by Prof. C. J. Gorter and by Dr. G. C. Garrett.

In the simple anti-ferromagnetics considered so far, the moments of the two sub-lattices are equal and opposite, so that the resultant spontaneous magnetization is zero. Two years ago, Prof. Néel introduced the idea[15] that many non-metallic 'ferromagnetics' may in reality be imperfectly compensated anti-ferromagnetics, or 'ferrimagnetics', as he calls them. At the conference he was able to show how fruitful this idea has been in explaining the properties of ferrites and other magnetic oxides. The metallic ions in the ferrite structure (Fe_2O_3, M++O) are distributed between two different types of site in the framework of oxygen ions, and Néel supposes that the ions in each type form a sub-lattice in the sense indicated above. Below the Curie point the material will have a spontaneous magnetization equal to the difference between the magnetizations of the two sub-lattices, and in many cases this differs from zero. The theory gives quantitative predictions about the variation of spontaneous magnetization with composition and temperature, the specific heat anomaly at the Curie point and the variation of susceptibility with temperature above the Curie point. Refinements to the theory allow for the effect of orbital as well as spin magnetic moment and for the variation of molecular field with temperature[17].

Experiments verifying many of these points were reported by Messrs. R. Pauthenet and L. Bochirol[18], Dr. E. F. Bertaut and Prof. Weil[19], working at Grenoble. More general studies of the properties of ferrites were described by Prof. M. Fallot, Dr. C. Guillaud[20] and Prof. A. Michel. In this work, as in that of Prof. R. Chevallier on α-Fe_2O_3, the difficulties in obtaining pure and homogeneous materials are great, leading at times to confusing results. A new non-metallic magnetic substance was reported by Dr. J. H. van Santen—the material $LaMnO_3$–$CaMnO_3$, with a perovskite structure, has a transformation point at about 300° K., below which it is ferromagnetic. Since neighbouring manganese atoms are separated by an oxygen atom on their line of centres, this is the first known case of indirect interaction due to pure superexchange; it is also the first case in which indirect interactions have been observed to be positive.

A general review of ferrites was given by Dr. J. L. Snoek, stressing the advances in basic theory but pointing out the problems of high-frequency behaviour still remaining. High-frequency phenomena were also considered in a report by Dr. C. Kittel on gyromagnetic resonance and an account by Mr. F. Roberts of experiments on the radio-frequency analogue of the

Faraday rotation of the plane of polarization by a magnetized medium.

At the end of the conference, Prof. Bates expressed very happily the gratitude which all the participants, particularly those from other countries, felt towards Prof. Néel and all who helped to organise the conference for the admirable arrangements and the very pleasant atmosphere which prevailed throughout both the formal sessions and the less formal intervals.

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STATISTICAL METHODS IN BIOLOGICAL AND CHEMICAL EXPERIMENTS

IN January 1949, the New York Academy of Sciences held a conference on "The Place of Statistical Methods in Biological and Chemical Experimentation"; the fifteen papers there presented are now published* "as a guide to those workers in the fields of biology and chemistry who wish to learn more about the place of statistics in research". The volume naturally does not give a connected account of the methods of statistical science, but it does provide exceedingly interesting illustrations of the many ways in which the statistician can help a research programme. It should be of value to the sceptic requiring to be weaned from his belief that "I don't need statistics in my work", to the teacher in search of examples, and also to the specialist who can appreciate the intrinsic merits of those contributions lying close to his own branch of study.

The first two papers, by G. W. Snedecor and G. M. Cox, are general accounts of the function of statistical analysis and experimental design. Next come several papers descriptive of special statistical techniques, in subjects as diverse as analytical chemistry, nutrition and immunology. Four papers on biological assay and three on studies of human populations complete the collection. All the authors have something worth saying, and all present their topics with admirable clarity; one or two need special mention.

Many readers will be interested to see F. W. Wilcoxon's survey of the approximate methods of analysis that he has done so much to develop. C. V. Winder contributes a valuable account of certain applications of statistics in pharmacology, in the course of which he discusses the choice of a metameter for analysis. L. C. Miller compares different techniques for the analysis of assays using quantal responses, making useful comment on the validity and utility of each. D. Mainland and D. D. Reid describe some of the statistical problems of research in clinical medicine, with special reference to recent progress in this important and difficult field.

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* Annals of the New York Academy of Sciences. Vol. 52, Art. 6: The Place of Statistical Methods in Biological and Chemical Experimentation. By Edwin J. de Beer, Lloyd C. Miller and 14 other Authors. Pp. 789–942. (New York: New York Academy of Sciences, 1950.) 2.25 dollars.

THE TSETSE FLY IN EAST AFRICA

THE report of the East African Tsetse and Trypanosomiasis Organisation for 1949* shows that an integrated attack is being made upon this many-sided problem—research and reclamation are being closely co-ordinated, the medical, veterinary and agricultural aspects are being treated as different facets of a single problem, and progress in East Africa is being correlated at each step with advances made in other parts of the continent.

As the director, Dr. H. M. O. Lester, points out, the broad aim of the Organisation is the assistance of development in East Africa; and the reorganisation of research which is in progress and, in particular, the closer liaison between tsetse research and trypanosomiasis research, are clearly having a stimulating effect. Detailed work with improved technique is in progress to define exactly the habitats of the different species of tsetse fly so as to make possible the eradication of the tsetse with the minimum interference with vegetation.

There are many questions in tsetse biology which must be answered before land-utilization policies can be formulated. It is already clear that the eradication of tsetse fly from any area has little value unless the land that has been freed from this pest is required for some specific purpose. Until more effective methods of applying insecticides and cheaper methods of clearance are developed, eradication and resettlement will only be economic where there is sufficient pressure of population for the organisation of large-scale undertakings. The effect of 'fire exclusion' in exterminating *Glossina swynnertoni* has been confirmed. As in Southern Rhodesia, it has been proved in an experimental fenced area of 560 square miles that the destruction of game animals leads to a very great reduction in the numbers of *G. morsitans* and the virtual collapse of *G. swynnertoni*.

On the veterinary side, extensive trials have been carried out on the prophylactic and curative value of the drug 'Antrycide'. A cautious attitude was adopted from the outset by the research organisation, and this attitude appears to have been justified. The drug has remarkable curative properties against veterinary trypanosomiasis, although severe toxic reactions have occurred and will require further study before its use on a large scale can be recommended. As a prophylactic the drug has proved disappointing. It is liable to cause prolonged incubation of the disease and so to mask infection; and acquired resistance is so readily developed by *T. congolense* and *T. vivax* that it appears difficult, if not impossible, to use the drug for large-scale prophylaxis in East Africa.

* East African High Commission: East African Tsetse and Trypanosomiasis Research and Reclamation Organisation. Annual Report, 1949. By Dr. H. M. O. Lester. Pp. 26. (Nairobi: East African High Commission, 1950.)

LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications

Cell Specificity of Histones

During the course of our investigations[1,2] on the chemistry of the cell nucleus, it was found[3] that the basic proteins present in the nuclei of the erythrocytes and liver cells of the salmon bear, in contrast to the protamin (salmine) known to be present in the sperm heads, the complete character of histones. At the same time, significant analytical differences were detected between the histones from the two types of cells. These results suggested to us the possibility that each nucleus possesses a basic protein characteristic of the type of cell of which it forms part. This is certainly true of the sperm head of the salmon, for protamin does not occur in other cell nuclei of this species. It appears also to hold for the nuclei of the erythrocytes and liver cells of this species, for the histones isolated from them exhibited marked differences, quite beyond the limits of analytical error, in their arginine contents. Nevertheless, before generalizing our results it seemed desirable to confirm them and, if possible, to extend them to other species. Unfortunately, we have not yet succeeded, despite many efforts, in obtaining a new specimen of fresh salmon blood. We have, however, examined the histones isolated from cell nuclei of other species with the results recorded below.

The assumption has hitherto been tacitly made that the histones extracted from isolated cell nuclei are individual proteins. In fact, however, every histone so obtained has now proved to be composite, consisting of two, and in one case three, components. All the components are basic proteins, and we therefore propose, at any rate provisionally, to describe them all as histones, the component present in preponderating amount being termed the main, and the others the subsidiary, histones. The sulphates of the main histones are less soluble in aqueous alcohol than those of the subsidiary ones and can therefore be obtained more or less readily in what appears to be a pure state. The subsidiary histones are more difficult to purify and have so far only been isolated in a state approaching purity in two instances.

Main and subsidiary histones differ strikingly in composition. Thus, in the products from the nuclei of ox thymocytes, the arginine content accounts for 30 per cent of the total nitrogen of the main histone but only 8 per cent of that of the subsidiary one, the basic properties of the latter being, in fact, mainly due to a high content of lysine. In contrast to this, the corresponding figures for the histones from the nuclei of fowls' erythrocytes are 26·5 per cent and 34 per cent. Here, the subsidiary histone contains considerably more arginine than the main one; but there is evidence of the presence in these nuclei of a third histone of the subsidiary type containing little arginine. Subsidiary histones with a small arginine content have been detected in the basic proteins of nuclei isolated from the following organs: spleen (ox and fowl); liver (ox and salmon); thymus gland (ox and fowl); sperm (cod); a tumour (man). There is thus little doubt that they are of general occurrence in the cell nuclei of animals; but since the majority of them have so far been obtained in insufficient quantity for complete purification, they at present yield no evidence of cell specificity. On the other hand, the subsidiary histone with high arginine content isolated from the nuclei of fowl erythrocytes is cell-specific, for it is absent from both the thymocytes and lymphocytes of the fowl.

The main histones are remarkably constant, both qualitatively and quantitatively, in amino-acid composition, although differences can in some, but not all, cases be detected between those obtained from different species. This is illustrated by their arginine contents shown in the accompanying table.

Arginine Contents of Main Histones

Species	Source of nuclei	Arginine-N as % of total N
Ox	Thymus gland	29·5
	Spleen	29·5
	Liver	30·0
Fowl	Erythrocytes	26·5
	Spleen	29·8
	Thymus gland	29·3
Cod	Sperm	28·6
Salmon	Liver	30·2
Man	Tumour	29·5
	Spleen	30·6

These figures clearly give no evidence of specificity among the main histones from different cells of the ox. No differences would, of course, be expected between those from the thymus gland and the spleen, because they are derived from cells (thymocytes and lymphocytes) which are morphologically identical. But the value for the histone from the liver, which might be expected to exhibit specificity, is, within the limits of experimental error, indistinguishable from those of the thymus gland and spleen. These identical arginine contents do not, however, necessarily prove the identity of the histones. On general grounds, it is almost certain that the histones from the various species are species-specific, yet the arginine contents do not permit us to distinguish between the histones from species so divergent as man, ox, fowl (spleen and thymus gland) and salmon. Whether the histones from the ox do, or do not, exhibit cell-specificity must therefore remain, for the present, an open question. On the other hand, there is no doubt that, in the fowl, the histones in the erythrocytes and lymphocytes are cell-specific between these two types of cells. This has been shown above for one of the subsidiary histones. It is also true for the main histones, as is evident from the differences in their arginine contents.

One important consequence of these results lies, in our view, in the possibilities they offer of filling a gap in current genetical theory. It has always been a puzzle to us, as chemists applying our techniques to the field of cytogenetics, how the physiological functions of cell nuclei in the same organism can differ—as presumably they do differ—from one cell-type to another when they all contain identical chromosomes and hence identical genes. The physiological functions of the nuclei are presumably due to the genes which they contain; they should, therefore, be identical in all nuclei of a given organism. If, however, it is postulated that nuclei contain some mechanism for the suppression of the activities of particular genes, or groups of genes, and that this mechanism is specific for each cell type, these difficulties disappear. The demonstration in the work outlined above that some of the basic proteins present in cell nuclei are certainly cell-specific leads to the hypothesis that one of their physiological functions is to act as gene suppressors. It is true that specificity

has not been demonstrated for all the histones examined; but, as we have pointed out, such specificity is not excluded by our work.

A full account of this work is in course of preparation for publication elsewhere.

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Carbohydrate and Adenosinetriphosphate in Sea-Urchin Semen

SEA-URCHINS differ from mammals, in which fertilization is internal and the survival of spermatozoa largely depends on extraneous nutrients provided by accessory secretions, in that fertilization takes place after the eggs and sperm have been shed into sea water, which is a poor source of organic nutrients. Furthermore, unlike mammalian spermatozoa which in most species, including man, obtain their metabolic energy through anaerobic and aerobic glycolysis[1], sea-urchin spermatozoa depend on a non-glycolytic and strictly aerobic metabolism; sea-urchin semen is devoid of significant amounts of fructose or other fermentable sugars; and the spermatozoa are incapable of glycolysing sugars added *in vitro*[2].

In a search for glycogen or other intracellular reserve carbohydrate, seminal plasma and spermatozoa, obtained by centrifugation of semen (*Echinus esculentus*), were hydrolysed with potassium hydroxide; the ethanol-precipitable material obtained from the alkaline solution was analysed by several methods. Total carbohydrate was estimated by means of anthrone[3]; 'reducing sugar', 'yeast-fermentable sugar' and glucose were determined after acid hydrolysis of the ethanol-precipitable material; the amount of 'reducing sugar' was small, being 110 mgm./100 ml. spermatozoa (110 mgm. per cent), of which only 40 mgm. per cent was glucose, identified by the yeast-fermentation test and glucose oxidase[4]. The oxidation of this amount of glycogen or glycogen-like material would be inadequate to account for the high oxygen consumption of sea-urchin spermatozoa[5,6]. The seminal plasma of *Echinus esculentus* contains little free reducing sugar and no glycogen-like material, though about 200 mgm. per cent of some other anthrone-reactive carbohydrate is present.

The content of hexose-phosphate phosphorus in sea-urchin sperm was also determined and found to be only 2 mgm. per cent.

Studies on mammalian spermatozoa have established that both their glycolytic metabolism and motility are related directly to their content of adenosinetriphosphate; in normal ram semen the concentration of adenosinetriphosphate varies from 0·5 to 1·5 mgm. per cent of adenine amino-nitrogen[7]. So far, the presence of adenosinetriphosphate in sea-urchin semen has been deduced only from the occurrence of a 'barium insoluble, acid-labile ester'[8]. To obtain precise information about adenosinetriphosphate in sea-urchin semen, an attempt was made to isolate it, following the procedure of Parnas and Lutwak-Mann[9] for the quantitative estimation of adenosinetriphosphate in skeletal muscle. In a trichloroacetic acid extract from 20 ml. semen of *Echinus esculentus*, adenosinetriphosphate was separated as barium salt, and after removal of barium, the pentose, pyrophosphate-phosphorus and amino-nitrogen were estimated in the solution. There were 9·9 mgm. pentose, 3·8 mgm. pyrophosphate-phosphorus and 0·93 mgm. of adenine amino-nitrogen per 100 ml. semen. The molecular ratio of these three agreed satisfactorily with the theoretical ratio 1 : 2 : 1. Adenosinetriphosphate therefore occurs as a normal constituent of sea-urchin semen in a concentration similar to that found in ram semen.

Adenosinetriphosphate is usually associated with glycolytic metabolism. The existence of significant quantities of this substance in sea-urchin spermatozoa raises the question of the role of adenosinetriphosphate in these spermatozoa, the metabolism of which, being non-glycolytic, is very different from that of mammalian spermatozoa, muscle or yeast.

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Gluconokinase and the Oxidative Path for Glucose-6-Phosphate Utilization

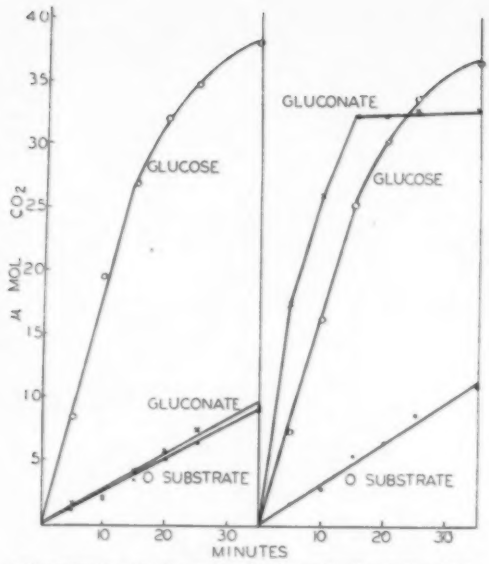
STUDIES of the oxidation of glucose-6-phosphate and 6-phosphogluconate by extracts of many types of cells have indicated the existence of an oxidative pathway leading through pentose phosphate to triose phosphate, in addition to the anaerobic steps of the Embden–Meyerhof scheme. We have recently obtained an indication of the potential importance of the oxidative pathway in the economy of the cell from a study of gluconate utilization in *Escherichia coli*, strain B.

When a moist sediment of *E. coli* grown in glucose medium[1] was ground by hand for two minutes with a fine grade of alumina, essentially all of the organisms were disrupted and many enzyme systems could be extracted with 0·01 *M* phosphate buffer at *p*H 7·0. Among these systems have been demonstrated the oxidizing systems for glucose-6-phosphate and 6-phosphogluconate, hexokinase, the systems for anaerobic conversion of glucose-6-phosphate to triose phosphate, and a weak adenosine pyrophosphatase. These systems have been found to have essentially similar activity in the extract from comparable numbers of gluconate-adapted bacteria. In addition, this latter extract contained an enzyme, gluconokinase, catalysing the reaction:

gluconate + adenosinetriphosphate → 6-phosphogluconate + adenosinediphosphate

The acid liberated in this reaction has been studied in Warburg respirometers (see graph).

Aliquots of the products of anaerobic gluconokinase activity on gluconate and adenosinetriphosphate



Acid-production in the enzymatic transphosphorylation from adenosinetriphosphate to gluconic acid by extracts of adapted and non-adapted bacteria. The reaction was measured at 38° in Warburg respirometers in bicarbonate buffer containing 8×10^{-4} *M* Mg^{++} equilibrated with 5 per cent carbon dioxide – 95 per cent nitrogen at pH 7·3. At zero time, 3·3 μmol. adenosinetriphosphate was added to 0·2 c.c. of bacterial extract (= $1·0 \times 10^{10}$ cells) and 10 μmol. substrate in 2·5 c.c. buffer. Left, extract of unadapted cells, grown in glucose; right, extract of adapted cells, grown in gluconate

were then analysed enzymatically. The reduction of triphosphopyridine nucleotide was followed spectrophotometrically at room temperature at 340 mμ in the presence of purified 6-phosphogluconate oxidizing system from yeast, inactive on gluconate.

As can be seen from the graph, addition of adenosinetriphosphate to the enzyme extract alone resulted in the liberation of 0·5 μmol. of acid in 15 min., due to the action of adenosine pyrophosphatase. In the presence of gluconate a total acid production of 3·2 μmol. had occurred in this time, indicating the presence of 2·7 μmol. of phosphogluconate. On spectrophotometric analysis of triphosphopyridine nucleotide reduction, it was found that the product contained 2·8 μmol. of oxidizable phosphogluconate.

The gluconokinase contents of the extracts were also studied by this spectrophotometric method. The addition of 0·001 *M* cyanide to the system was desirable to minimize the re-oxidation of the coenzyme by the oxidizing systems of undiluted extracts.

Assuming that extraction of hexokinase and gluconokinase was essentially complete and that the turnover numbers and molecular weights of bacterial hexokinase and gluconokinase were comparable to these values for yeast hexokinase[2], it was calculated that an adapted cell contained of the order of a thousand molecules of each of these enzymes. The sensitivity of our analytical methods suggests that the unadapted cell contained less than fifteen molecules of active gluconokinase; indeed, no evidence was obtained for the existence of this enzyme in the unadapted cell.

When *E. coli* is adapted to gluconate, the cells are not simultaneously adapted to D-arabinose, arabonate, 2-ketogluconate or 5-ketogluconate. Thus the adaptation seems to consist entirely of the formation of gluconokinase, a transphosphorylating enzyme which effects the formation of 6-phosphogluconate from gluconic acid and adenosinetriphosphate. Phosphogluconate does not disappear anaerobically nor aerobically in the absence of oxidized triphosphopyridine nucleotide, and appears to be used exclusively via the oxidative path through pentose phosphate, thereby completely by-passing that part of anaerobic glycolysis resulting in triose phosphate formation.

When *E. coli* is grown aerobically in a complete mineral medium containing gluconate as the sole source of carbon, the mass duplication time is found to be 57 min., as compared to 49 min. with glucose. The turbidity increments per mole of substrate are essentially identical, both substrates providing similar quantities of assimilable carbon. Thus the rate of utilization of this carbon from gluconate by the single oxidative path approached the rate of utilization of carbon from glucose, which could be degraded both by the oxidative path and by anaerobic glycolysis.

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Structure of the Mycolic Acids of Mycobacteria

R. J. ANDERSON[1] gave the name 'mycolic acid' to a high-molecular weight fatty acid (m.p. 58°), isolated from the *H* 37 strain of *Mycobacterium tuberculosis* var. *hominis*. The structural features of mycolic acid, as elucidated by him, are as follows: its probable formula is $C_{82}H_{164}O_4$, with one —COOH, one —OH and one —OCH_3 group; pyrolysis at 300° in a vacuum gives a volatile distillate (m.p. 88°), identified as *n*-hexacosanoic acid, $C_{26}H_{52}O_2$. Chromic acid oxidation breaks up mycolic acid into smaller fragments, among which the following could be identified: stearic acid, *n*-hexacosanoic acid and hexadecane, 1, 16-dicarboxylic acid[2].

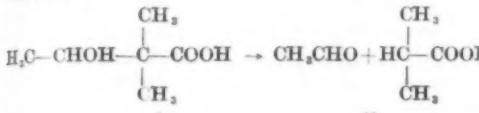
Bovine[3], avian[4] and other strains of Mycobacteria[5,6] contain similar high-molecular weight mycolic acids, the most characteristic feature of which is that they contain a hydroxyl group and that the pyrolysis reaction gives either *n*-hexacosanoic acid or similar acids[3-7].

Nothing was known about the position of the hydroxyl group or the structural significance of the pyrolysis reaction. We can now answer both questions.

In the course of an extensive study of the lipids of different strains of Mycobacteria, we described a chromatographic method of isolation of mycolic acid[8] and then the chromatographic separation of two probably isomeric (α and β) mycolic acids, differing in melting points and the melting points of their derivatives[9]. The elementary analyses of these chromatographically purified mycolic acids and of several of their derivatives confirm the formula $C_{82}H_{164}O_4$ proposed by

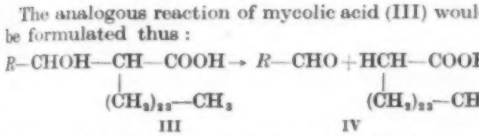
R. J. Anderson[1]. This formula is, of course, considered only as the most probable one; elementary analyses leave an uncertainty of about ± 5 C and ± 10 H.

We have shown quite recently that the hydroxyl group of mycolic acid is in the β-position to the carboxyl group[10]. This led us to the hypothesis that the thermal splitting-off of *n*-hexacosanoic acid (for which the presence of the hydroxyl is essential[3]) is analogous to the well-known pyrolysis of β-hydroxy-α,α dialkyl acids[11]. Thus, for example, (I) decomposes on heating into acetaldehyde and *iso*butyric acid (II)[12].



I II

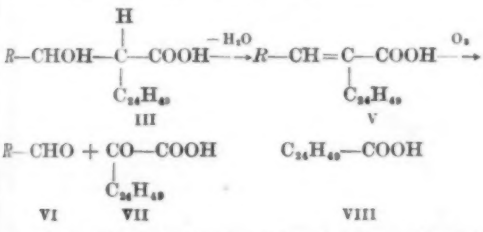
The analogous reaction of mycolic acid (III) would be formulated thus:



III IV

The real course of the reaction seems to be more complicated, as we have found no aldehyde, but a mixture of methoxyl-free substances.

We have now proved the structure (III) for mycolic acid through the following sequence of reactions: on heating mycolic acid with acetic anhydride containing 10 per cent potassium hydrogen sulphate, water is split off and the α,β unsaturated anhydromycolic acid (V) is formed[8,10]. Both isomers (α and β) seem to give the same anhydromycolic acid[9,10]. Ozonization of anhydromycolic acid (V) should give either α-oxo-hexacosanoic acid (VII) or, by further oxidation, *n*-pentacosanoic acid (VIII).



III V

VI VII VIII

In fact, after ozonization of anhydromycolic acid (V), we have isolated an acid (m.p. 82–83°), which has been identified by X-ray diffraction measurements as *n*-pentacosanoic acid (VIII) (found: C, 78·22; H, 12·92 per cent; $C_{25}H_{50}O_2$ requires C, 78·47; H, 13·17 per cent). α- and β-mycolic acids are thus β-hydroxy-α-*n*-tetracosyl-acids (III).

The C_{62} fragment (VI) of the molecule which is formed by ozonolysis of anhydromycolic acid (V) still contains one methoxyl group and at least one side-chain; the Kuhn–Roth C—CH_3 determination of mycolic acid shows the presence of at least three chains[13].

All mycolic acids described by R. J. Anderson[1,3–6] and the new mycolic acids which we have isolated[14] are characterized by the pyrolysis reaction leading to a long-chain normal fatty acid[7]. We may thus define mycolic acids as high-molecular weight β-hydroxy fatty acids with a long α-side-chain. This seems to be quite a new feature among natural fatty acids.

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[13] From a monolayer and X-ray study of mycolic acid, S. Ställberg-Stenhagen and E. Stenhagen (*J. Biol. Chem.*, **159**, 255; 1945) concluded that: "the cross-section of the molecule at no part of its length can be larger than that occupied by three parallel hydrocarbon chains".
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Cytochemical Localization of β-Glucuronidase

Applying histochemical techniques devised by Friedenwald and Becker[1], it was found[2] that in normal male mouse liver (Fig. 1) and kidney, β-glucuronidase activity is mainly confined to the mitochondria. It was considered that the rise in glucuronidase activity shown by biochemical methods to occur in these organs when repair has commenced subsequent to damage[3] might be reflected in a change in the cytochemical picture. This has been found to be the case in experiments with frozen sections

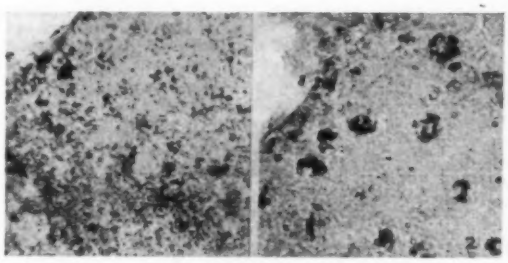

Fig. 1. Staining of mitochondria in 20-μ frozen section of normal male mouse liver. 8-Hydroxyquinoline glucuronide method. 8½ hours incubation. Yellow filter, × 500

Fig. 2. Staining of chromatin in 20-μ frozen section of regenerating male mouse liver, 7 days after administration of carbon tetrachloride 5·3 gm./kgm. in olive oil. 8-Hydroxyquinoline glucuronide method. 8 hours incubation. Yellow filter, × 500

In both figures a portion of central vein is at the upper left

of mouse liver regenerating after partial hepatectomy or carbon-tetrachloride poisoning, using 8-hydroxyquinoline glucuronide as substrate. In contrast to the mitochondrial site in normal liver, β-glucuronidase activity as detected by this method now appears to correspond in situation to the nucleus (Fig. 2). This did not result from aggregation of the mitochondria, which were seen to be normally situated in sequent sections stained with Iron Hæmatoxylin after fixation in Regaud's fluid. On the other hand, Feulgen staining in regenerating liver gave a similar picture to that obtained by the glucuronidase method. Normal liver sections stained by the Feulgen method did not in any way resemble those obtained histochemically.

It should be noted that biochemical methods suggest that mitochondrial glucuronidase activity remains at the normal level in regenerating liver, whereas the fraction of the enzyme which is soluble in acidified water homogenates rises in activity[4]. The apparent discrepancies between the results obtained by the two techniques will form the starting point for further investigation.

One of us (J. G. C.) is in receipt of a full-time grant from the British Empire Cancer Campaign.

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Inhibition of Chymotrypsin by Diethyl *p*-Nitrophenyl Phosphate

CHYMOTRYPSIN displays both esterase and proteolytic activity, and it has recently been shown[1] that this enzyme is inhibited by di*iso*propyl fluorophosphonate and that loss of esterase activity is paralleled by loss of proteolytic activity. Diethyl *p*-nitrophenyl phosphate (*E*.600) resembles di*iso*propyl fluorophosphonate in being a very powerful anticholinesterase. We have found that it will also inhibit chymotrypsin, and have been studying the system chymotrypsin – diethyl *p*-nitrophenyl phosphate as a convenient model for other esterase systems, since the physical data for this enzyme (purity, molecular weight, etc.) are among the more accurately known.

Our sample of crystalline chymotrypsin was found to be 50·2 per cent pure (the remainder being magnesium sulphate) by using Anson's method of estimation[2] (digestion with denatured hæmoglobin in phosphate buffer, *p*H 7·7 at 25°, and using Northrop's value of $(0{\cdot}038\ \text{T.U.})^{\text{Hb}}_{\text{mgm.P.N.}}$ for the activity of pure enzyme). The inhibitory effect of diethyl *p*-nitrophenyl phosphate was followed by incubating the enzyme in buffer *p*H 7·7 at 25° for 18 hr. and the proteolytic activity estimated as above. A concentration of diethyl *p*-nitrophenyl phosphate of 8×10^{-6} *M* gave 50 per cent inhibition of 0·1 per cent chymotrypsin under the above conditions. A yellow colour developed in the solutions during incubation and the absorption spectrum corresponded to that of nitrophenol. Measurement of the absorption at 400 mμ using a Beckmann photo-electric absorptiometer was a convenient method for the assay of nitrophenol. It was found that more nitrophenol was liberated in the presence of the enzyme than in its absence; the results of a typical experiment were as follow.

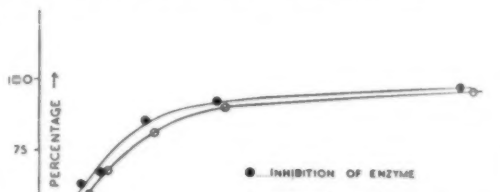
	Solution	Nitrophenol concentration observed
(*a*)	Chymotrypsin (0·993 mgm./ml.) + *E*.600 (10^{-3} *M*) in phosphate buffer *p*H 7·7 incubated for 18 hr. at 25°	$3{\cdot}00 \times 10^{-4}$ *M*
(*b*)	Control, as above, but omitting chymotrypsin	$1{\cdot}17 \times 10^{-6}$ *M*
	Extra nitrophenol produced in (*a*)	$1{\cdot}83 \times 10^{-4}$ *M*
	Inhibition of enzyme after 18 hr. = 100 per cent.	

Using a value of 27,000 ± 1,000 for the molecular weight of the chymotrypsin (see Jansen *et al.*[2]) and assuming an equation:

$$\text{Chymotrypsin} + (\text{EtO})_2\text{PO.OC}_6\text{H}_4\text{NO}_2 = \text{(Inhibited chymotrypsin-PO(OEt)}_2\text{)} + \text{HO.C}_6\text{H}_4\text{NO}_2$$

the theoretical concentration of nitrophenol expected would be $(1{\cdot}81 \pm 0{\cdot}07) \times 10^{-5}$ *M*.

Simultaneous determinations were made of the nitrophenol liberated and the percentage inhibition of the enzyme during 18 hr., and the results are shown in the accompanying graph. The two curves are essentially coincident, and a linear relationship is found on plotting nitrophenol liberated against percentage inhibition. These results suggest that there may be only one 'active centre' in the chymotrypsin molecule, in agreement with the findings of Jansen *et al.*[3], who found that chymotrypsin inhibited with di*iso*propyl fluorophosphonate containing phosphorus-32 had 1·1 atoms of marked phosphorus to 1 molecule of enzyme after recrystallization.



As a working hypothesis of the mechanism of esterase activity, we think it probable that one molecule of substrate reacts at the active centre of the enzyme and hydrolysis occurs. Normally, both the alcohol and acid moieties then leave the active centre and the cycle is repeated; but if certain inhibitory substrates are used, such as diethyl *p*-nitrophenyl phosphate or di*iso*propyl fluorophosphonate, the acid portion of the substrate (that is, $-\text{PO(O}R)_2$) remains attached after hydrolysis and blocks the active centre, while the other portion (for example, nitrophenol or hydrogen fluoride ?) is liberated. Further work on the kinetics of the reaction and the use of radioactive inhibitors is in progress.

Our thanks are due to Armour and Co., of Chicago, for a gift of crystalline chymotrypsin, and to the Agricultural Research Council for financial support.

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Beta- and Gamma-Globulin Tetanus Antitoxin of the Hyperimmune Horse

PAST work has indicated that fractionation of diphtheria antitoxic horse serum yields fractions of which the dilution ratio, and hence the firmness of combination, may show considerable variations. There was a definite correlation between the *in vitro*/*in vivo* ratio and the dilution ratio[1]. Kekwick and Record[2] examined electrophoretically pure gamma- and beta-globulin from hyperimmune horse sera, and found that both fractions had antitoxic activity and that they differed in their $L+/L_f$ ratios and in their speed of flocculation. It was of interest to investigate whether this was a general phenomenon, or one confined to the diphtheria toxin–antitoxin system, by studying the relation between tetanus toxin and horse tetanus antitoxic sera.

Qualitative differences between tetanus antitoxic sera have been observed by Hartley (quoted in ref. 3) and Petrie[4]. Dilution tests[5] on two sera and two fractions from one of them indicated a similarity to the diphtheria toxin–antitoxin system, and Kekwick[6] demonstrated that both gamma- and beta-globulin were antitoxic.

Gamma- and beta-globulin were obtained by fractionation with sodium sulphate followed by electrophoretic separation[2,6] from sera of horses hyperimmunized intramuscularly with tetanus toxoid. Flocculation always gave multiple zones. The flocculation zone due to tetanus toxin was determined by preparing floccules near each of the indicating mixtures, using proportions providing excess of toxin or antitoxin. The floccules were washed and then added to a suitably diluted solution of antitoxin. Toxin–antitoxin floccules absorb considerable quantities of antitoxin and may be distinguished in this way from floccules derived from flocculation zones involving other antigens[7]. L_f and K_f were determined at 49° C. in phosphate buffer, $I = 0{\cdot}2$, pH 8.

The extent to which toxin–antitoxin dissociates on dilution was tested in two ways: (1) the amount of an antitoxin was found that would neutralize an $L+/5$ dose of toxin and was compared with the amount required to neutralize an $L+/250$ dose of toxin[5]; (2) the amounts required to neutralize the test dose of toxin in the mouse and in the guinea pig were compared. (M/G is ratio of $L+$units per ml. in the two cases.[4])

Antitoxin	K_f	$\frac{L+\text{units per ml.}}{L_f}$		$\frac{M}{G} \times 100$	$\frac{L+/250}{L+/5} \times 500$
		a	*b*		
'Keeble' serum	145′(1)	1·5	2·2	87	68
'Keeble' gamma-globulin	69′(2)	2·6	4·4	60	55
'Keeble' beta-globulin	165′(1)	1·2	1·3	106	95

(1) 6 units/ml. of flocculation mixture.
(2) 4·2 units/ml. of flocculation mixture.
(*a*) Determined from $L+/5$ measurements.
(*b*) Determined from $L+/250$ measurements.

It may be concluded that, in flocculating, tetanus–toxin–antitoxin systems resemble diphtheria toxin–antitoxin mixtures. The gamma-globulin combines more avidly than the beta-globulin with the toxin; it dissociates *less* on dilution.

This work will be presented in detail elsewhere. Our thanks are due to Dr. R. A. Kekwick for suggesting this investigation and for his encouragement.

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July 4.

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Connective Tissue Permeability and the Mode of Action of Hyaluronidase

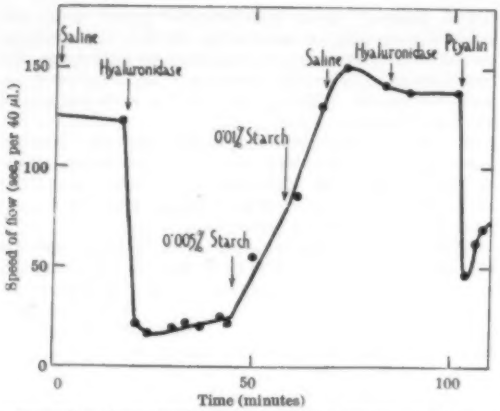
THE following observations would seem to throw fresh light upon the question of the mode of action of hyaluronidase on connective tissue permeability.

A sheet of fresh fascia from the flank of a mouse was fixed as an occluding membrane across the end of a glass tube of some 0·5 cm. internal diameter: rubber rings were found to be the best method of sealing the membrane to the tube. Particular care was taken not to damage the membrane during dissection or to stretch it unduly afterwards.

Fascial membranes prepared in this way were always found to be permeable to physiological saline, and at a pressure of 12 cm. water the rate of flow through them was of the order of 60 c.c. per min. This rate was almost immediately increased by some ten times when hyaluronidase (Benger's 'Hylase', 10 units per ml.) was added to the saline perfusate. The same result was obtained with a saline extract of mouse testis.

This effect of hyaluronidase was counteracted by dilute solutions of certain substances of large molecular size. Thus when the following substances, at the w/v per cent concentration indicated, were perfused, the original state of permeability was restored within an hour: starch, 0·005 per cent; agar, 0·01 per cent; gum arabic and citrus pectin, 0·05 per cent; leaf gelatine, 0·1 per cent; chondroitin sulphate and dried serum, 0·2 per cent. Mouse serum at a dilution of 1/40 and human synovial fluid at 1/100 were similarly effective.

In the case of synovial fluid, and to some extent with serum and pectin, the slowing of flow was partly due to viscosity, since it took place rapidly and normal flow was restored almost at once when saline was substituted. But with starch, agar and gum arabic the slowing was gradual, regular and also permanent, inasmuch as no quickening of flow took place when saline was again perfused.



Connective tissue membrane perfused at a pressure of 12 cm. water. Acceleration of flow caused by hyaluronidase counteracted by dilute starch. Flow afterwards accelerated by ptyalin

With the exception of synovial fluid, where a slight effect was observed, hyaluronidase had no further accelerating action upon the slowed rate of flow brought about by perfusion with these substances. But it was found that ptyalin (human saliva diluted by 1,000) had an effect upon a starch-treated membrane which imitated the former action of hyaluronidase precisely (see graph).

It is apparent that certain substances of large molecular size can, even in considerable dilution, slow the rate of flow when passed through a fascial membrane. This effect is independent of viscosity, and in the case of starch was clearly due to the accumulation within the membrane of starch molecules or molecular aggregates. There is no reason to doubt that the same mechanism was mainly responsible for the slowing action of the other substances mentioned with the exception of synovial fluid, with which viscosity effects predominated.

Connective tissue may be looked upon as a fabric of protein fibres[1], and it would seem that some degree of 'water-proofing' of the fabric by large molecules is possible. On this view, the sudden rheological effect of hyaluronidase, an effect, one would think, far too rapid to indicate the action of this enzyme on any very great quantity of substrate, is due to removal of those hyaluronic acid molecules which normally, to some extent, 'waterproof' the fabric. It is significant that, after treatment with hyaluronidase, the normal permeability of the tissue could be quickly restored by concentrations of serum far smaller than found in most pathological exudates. In spite of its dramatic effects on fresh tissue, it would seem, therefore, that hyaluronidase must be of negligible importance in relation to the spread of such exudates.

A detailed account of these findings will be published in due course. I wish to thank Dr. C. R. Boyes, of Messrs. Allen and Hanburys, Ltd., for providing me with citrus pectin and chondroitin sulphate, and Dr. Frank Fletcher, of Benger's, Ltd., for a supply of 'Hylase'.

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Phosphorylation and Absorption of Sugars in the Rat

It is known that the absorption of sugar from the intestine is accompanied by an increased phosphorylation of sugar in the mucosa[1-3]; but the evidence available does not show clearly if this phosphorylation plays a direct or an indirect part in absorption. It was felt that an examination of the properties of the hexokinase of the mucosa might help in deciding this question.

Homogenates of rat intestinal mucosa (1 gm. of tissue in 4 ml. homogenate) were employed, hexokinase activity being followed by the disappearance of free sugar from the digest in the presence of adenosinetriphosphate, using the method of Nelson[4]. The digest was incubated at 30° C. in open test tubes, and contained veronal-acetate buffer *p*H 8·0, 0·05 *M*; magnesium chloride, 0·01 *M*; sodium fluoride 0·06 *M*; as well as appropriate concentrations of sugar and adenosinetriphosphate. Total volumes of 1·5–2·5 ml. were used, of which one-third by volume was homogenate. No sugar disappearance occurred in the absence of adenosinetriphosphate. High concentrations of adenosinetriphosphate were required, because of the intense adenosinetriphosphatase activity of the homogenate. The phosphatase activity present did not interfere markedly with the sugar disappearance during the first 10 min. of the hexokinase reaction.

Water homogenates were used for studying the phosphorylation of D-glucose, D-fructose, D-mannose and D (−) xylose. At a sugar concentration of 0·0055 *M*, and an adenosinetriphosphate concentration of 0·033 *M*, the average hexokinase activity towards glucose was 0·80 ± 0·12 mgm. glucose disappearing per millilitre homogenate in 5 min. (15 rats). Water homogenates gave no activity towards D-galactose, as was found by Meyerhof with brain[5]; but, as with brain, good activity was obtained when Meyerhof's magnesium Ringer solution was employed in the preparation of the homogenates. These Ringer homogenates gave an activity towards glucose of 0·64 ± 0·07 mgm. glucose disappearing per millilitre homogenate in 2·5 min. (13 rats). The phosphorylation rates of the other sugars, measured under the same experimental conditions, relative to that of

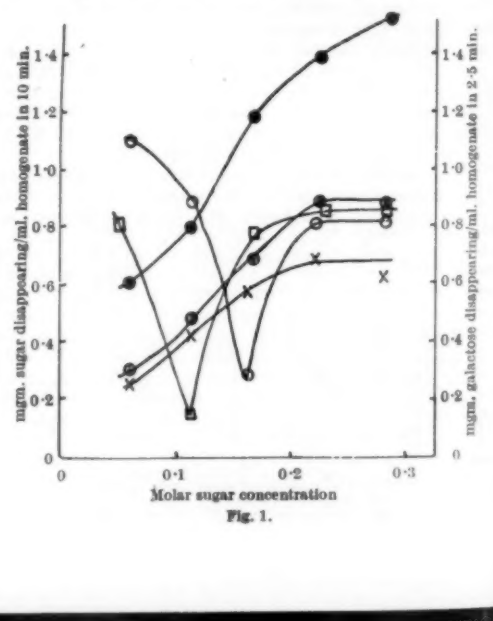

Fig. 1.

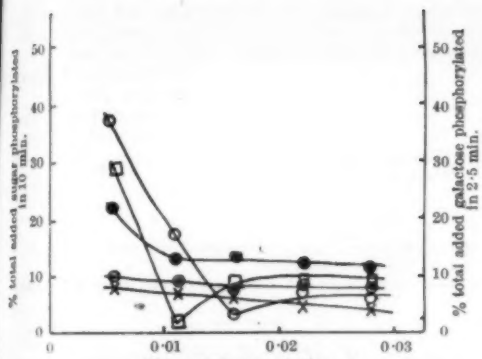

Fig. 2

glucose (= 100), are given in the accompanying table. The relative absorption rates, determined on 29 rats of the same stock, are included for comparison. Similar relative absorption rates are given in the literature[1,7]. The technique of Cordier and Touzé[6] was used to determine the absorption rates. It was found that a group of five rats would absorb 57 ± 5 mgm. glucose in 30 min. from 2 ml. of a 0·33 *M* (isotonic) solution injected into the small intestine. Other sugars were examined in the same way. The observed hexokinase activity was sufficient to account for the phosphorylation of at least 59 per cent of the glucose absorbed in 5 min.

Relative Phosphorylation and Absorption Rates

	Galactose	Glucose	Fructose	Mannose	Xylose
(a)	—	100	53	32	29
(b)	134	100	50	—	—
(c)	112	100	52	25	26

(a) Phosphorylation rates in water homogenates.
(b) Phosphorylation rates in Ringer homogenates.
(c) Absorption rates.

The accompanying diagrams show the effect of raising the sugar concentration upon the phosphorylation rates of the sugars. The 'dip' in the glucose concentration curve was observed in 22 out of 25 rats examined, and is flattened when the concentration of adenosinetriphosphate is raised. The phosphorylation-rates of the different sugars are found to vary with sugar concentration in much the same way as do their absorption rates[1].

The effect of variation in concentration of adenosinetriphosphate upon the rate of the hexokinase reaction depends upon the sugar concentration, and is different for different sugars. At a sugar concentration of 0·0055 *M*, the rate of the reaction with fructose remains constant over a concentration range of 0·013–0·04 *M* adenosinetriphosphate; but the rate with glucose varies with the concentration of adenosinetriphosphate. Meyerhof (*loc. cit.*) found brain homogenates to behave in a somewhat similar manner, alterations in the concentration of adenosinetriphosphate affecting the glycolysis rates with glucose and fructose differently, at the same sugar concentration.

Phosphatase activity was studied in a manner similar to that used for hexokinase, without adenosinetriphosphate, the appearance of free sugar in the digest being followed. Sugar is set free from glucose-6-phosphate and from fructose-6-phosphate at the same rate; at an ester concentration of 0·0055 *M* this is equivalent to 0·75 mgm. sugar appearing per millilitre homogenate in 5 min.

These observations suggest that hexokinase participates directly in sugar absorption, and with the phosphatase functions in a phosphorylation-dephosphorylation cycle. The absorption rates of different sugars are determined by the behaviour of the hexokinase, which may, in its turn, be influenced by the amount of adenosinetriphosphate available *in vivo*.

These results will be reported in detail elsewhere.

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Bacteriostatic Substances in the Unsaponifiable Fraction of Cod-liver Oil

We have investigated the unsaponifiable fraction of cod-liver oil and found that it has a strong bacteriostatic effect; especially interesting is the fact that *in vitro* it suppresses growth of *M. tuberculosis*. The non-saponifiable matter was chromatographed over alumina, the fraction most firmly held having the strongest activity. This fraction was a viscous oil and did not contain sterols, vitamin A or vitamin D. Only hydroxylic compounds (probably chiefly unsaturated) were present, and among these α-glyceryl ethers were found. After hydrogenation the bacteriostatic effect decreased considerably. The fraction inhibited the growth of *M. tuberculosis* in concentrations of 1–3 μgm. per ml. Sauton medium.

In animal experiments (guinea pigs) a daily dose of 30 mgm. was not active against infection with tubercle bacilli; moreover, the substance proved to be more or less toxic.

Details will be published elsewhere.

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The Xylan of *Rhodymenia palmata*

Barry and Dillon[1] reported the isolation from the red seaweed *Rhodymenia palmata* of a polysaccharide which gave D-xylose on hydrolysis. Our special interest in xylans[2] has led us to investigate this substance more fully as part of the research programme of the Scottish Seaweed Research Association. Since work on this subject has also been continued in University College, Galway, we have agreed with Prof. T. Dillon to publish a preliminary account of our findings.

The polysaccharide, $[\alpha]_D$ − 96° (H_2O) (*cf.* esparto xylan $[\alpha]_D$ − 91° (NaOH)) gave xylose only on hydrolysis. Periodate oxidation showed that 80 per cent of the xylose residues possess α-glycol groupings

and these are linked, therefore, through $C_{(1)}$ and either $C_{(2)}$ or $C_{(4)}$, if the possibility of the presence of furanose residues is discounted. The resistance to attack of the remaining 20 per cent can be explained only by the presence of 1 : 3-linkages.

Complete methylation and hydrolysis gave 2-methyl-, 2 : 3-dimethyl-, 2 : 4-dimethyl-, and 2 : 3 : 4-trimethyl-D-xylose, the proportion of the last compound agreeing with the presence of one non-reducing end-group for every 20–21 xylose residues. This separation was achieved by filter-paper chromatography; a more detailed analysis must await the use of the cellulose column. It is evident, however, that this marine xylan contains both 1 : 3- and 1 : 4-unions between the xylose units, and that even apart from this difference in its general structure, it differs from esparto xylan[2]. The possibility that the substance examined is a mixture of two xylans built up with 1 : 3 and 1 : 4-linkages respectively appears to be discounted by the fact that careful fractionation of both the acetate and the methyl derivative failed to effect any separation. In a general way, therefore, this xylan appears to be analogous to lichenin[3], which has been shown to contain D-glucopyranose units linked through the 1 : 3- and 1 : 4-positions in the proportion of about 1 in 3.

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[2] Chanda, Hirst, Jones and Percival, *J. Chem. Soc.*, 1289 (1950).
[3] Meyer and Gürtler, *Helv. Chim. Acta*, **30**, 751 (1947). Boissonnas, *ibid.*, 1703 (1947).

As obtained by us, the xylan of *R. palmata* after purification contained 0·5 per cent of ash and had $[\alpha]_D$ − 99·3° (c = 1·44 H_2O). Methylation followed by hydrolysis gave the same methyl xyloses as those obtained by the Edinburgh workers, and they were roughly estimated to be in the same proportion.

The xylan was partially oxidized by periodic acid, and the oxidized product gave with ammonia a white precipitate which, after purification, contained 2·7 per cent of nitrogen. This substance was assumed to be an aldehyde ammonia formed by the combination of two molecules of ammonia with each pair of aldehyde groups produced by the oxidation, and on this basis it was calculated that one xylose residue in seven was vulnerable to periodic acid. In view, however, of the much higher figure for α-glycol units found by Percival and Chanda, it must be assumed that only a small fraction of the total aldehyde groups combine with ammonia before precipitation arrests further action.

Titration of the formic acid produced by oxidation with potassium periodate[1] gave 1 mole of formic acid to 7 xylose residues, while determinations of the formaldehyde produced by periodate oxidation (at the reducing end of the chain)[2] gave 1 mole to 39–40 residues.

These results suggest that this xylan has a structure similar to that proposed by Chanda, Hirst, Jones and Percival[3] for esparto xylan, namely, a chain of xylose anhydride units with one branch. The algal xylan, however, appears to contain only about 40 xylose units in the molecule as against 75 in the esparto product. The high proportion of formic acid points to a linkage at the reducing end through $C_{(4)}$, which would yield 2 moles of formic acid, rather than through $C_{(3)}$, which would yield 1 mole only.

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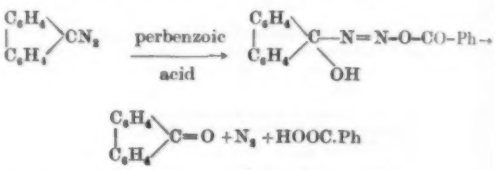
[1] Halsall, Hirst and Jones, *J. Chem. Soc.*, 1427 (1947).
[2] Bell, *J. Chem. Soc.*, 992 (1948).
[3] Chanda, Hirst, Jones and Percival, *J. Chem. Soc.*, 1289 (1950).

Action of Perbenzoic Acid on Diphenylene Diazomethane

When an ice-cold benzene solution (12 c.c.) of perbenzoic acid (0·6 gm.) was added (during a period of 5 min.) to a benzene solution (12 c.c.) of diphenylene diazomethane (0·5 gm.) at 45°, a vigorous evolution of gas was observed. The temperature was kept at 45° for a further 10 min. and benzoic acid removed by extraction with sodium carbonate. The product was dried *in vacuo* and the residue recrystallized from dilute methyl alcohol yielding fluorenone (0·15 gm.).

This seems to be the first case where $>CN_2$ has been directly transformed to $>C=O$.



$$\begin{array}{l}C_6H_4\\|\\C_6H_4\end{array}\!\!>\!C{=}O + N_2 + HOOC.Ph$$

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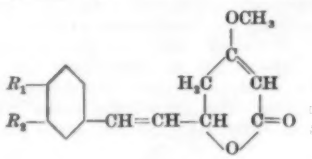
Synthesis of Kawain

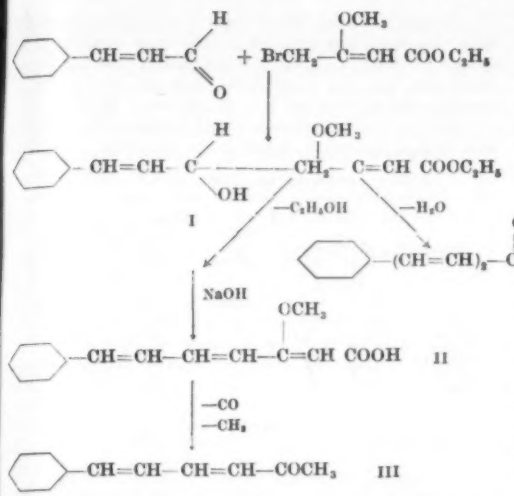
During 1914–33 Borsche[1] isolated several structurally related substances from kawa resin. He proposed the general formula:



for example, kawain (I): R_1=R_2=H

Neither Borsche nor the other workers in this field have synthesized any of these substances.

It occurred to us that a relatively simple synthesis should be possible by a Reformatzky condensation between cinnamic aldehyde or its derivatives and ethyl-γ-bromo-β-methoxycrotonate. Under the conditions of the reactions the initial condensation



product was expected to lose water, giving the triply unsaturated ester IV, or to split off alcohol, thereby giving the lactone I.

We have carried out this condensation and were able to isolate in small yield a substance of formula $C_{14}H_{14}O_3$ (calc.: C, 73·0; H, 6·1; OCH_3, 13·5; found: C, 72·8; H, 6·2; OCH_3, 14·0). However, the melting point was 145°, whereas Borsche[2] gives the melting point as 102° for kawain.

When heated with a solution of sodium hydroxide, the substance behaved as a lactone. We were able to isolate the free acid (II) as pale yellow crystals (m.p. 184°). The kawaic acid obtained by Borsche in a similar manner from kawain is described as a yellow substance (m.p. 185°).

By decarboxylation and demethylation of this acid we obtained the ketone (III), likewise obtained by Borsche from kawaic acid. It was identified as its 2.4.dinitrophenylhydrazone (m.p. 218°).

There seems, therefore, no doubt that a synthesis of the substances from kawa resin is now possible.

A detailed account of this work will appear elsewhere. Work on these syntheses is being continued.

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[1] Borsche, W., *Ber.*, **47**, 2902 (1913); thirteenth and last publication, *Ber.*, **66**, 803 (1933).
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A New Colour Reaction for Methylthiouracil

Little information is available on the excretion of methylthiouracil, particularly after its administration in hyperthyroidism. Since the drug is now widely prescribed for the reduction of hyperthyroid and thyrotoxic states, we have been interested in the development of a colour reaction for it capable of adaptation on a quantitative basis. Up to the present, colorimetric methods for the determination of thiouracil and propylthiouracil have been based upon the original procedure of Anderson[1], who applied Grote's reagent[2] for the determination of thiourea and compounds containing the C=S group to the determination of thiouracil in urine. Methods using Grote's reagent, however, are subject to a number of disadvantages, the chief of which are: (1) instability of the stock reagent; (2) tedious adjustment of the reaction; (3) preparation of standards for each set of determinations. Except for the procedure of Williams *et al.*[3], all workers report an unstable reagent; the method of Williams *et al.* has the disadvantage of a 12-hr. digestion procedure. Since the colour reaction described in this communication represents a new approach to the subject, previous work will not be discussed further.

The reaction between pyrimidines and 2 : 6-dichloroquinone-chloroimide has been under investigation. Recently this work was extended to include 2-thiouracil and the 4-methyl derivative of the latter. It has been found that when small amounts of the drugs in a borate buffer (*p*H 8·0) are treated with a solution of 2 : 6-dichloroquinone-chloroimide in ethanol, soluble yellow-coloured products are obtained. Fearon[4] has shown that uric acid reacts with the chloroimide reagent under similar conditions with the formation of an orange/yellow-coloured product. The same author[4] applied the reaction to the determination of uric acid in urine, and noted that thiourea, creatinine, and a number of other urinary solutes also gave coloured products in the reaction. I have found, however, that the yellow-coloured products obtained with thiouracil and methylthiouracil in the reaction are readily soluble in chloroform, whereas those due to uric acid, creatinine, and the majority of urinary solutes are completely insoluble. By this means the colour reaction for thiouracil and methylthiouracil has been rendered specific. Using this reaction, it has been found possible to determine with accuracy methylthiouracil in urine; details of the method will be published elsewhere. The sensitivity of the reaction for methylthiouracil is in the region of 10 μgm., and as a result the reaction is applicable to the determination of this drug in plasma; this work will be described elsewhere.

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Chromatographic Separation of the Saturated C_3–C_6 Fatty Acids from a Single Small Sample

In order to study some aspects of nematode metabolism, we found it necessary to analyse quantitatively single small samples of mixed fatty acids which varied in constitution from acetic to octanoic. The only quantitative method reported[1] is time-consuming and unsuitable for a large number of analyses. It has now been possible to extend the procedures described by Ramsey and Patterson[2] and

Elsden[3], so that a single sample containing the acids mentioned above can be analysed in two hours.

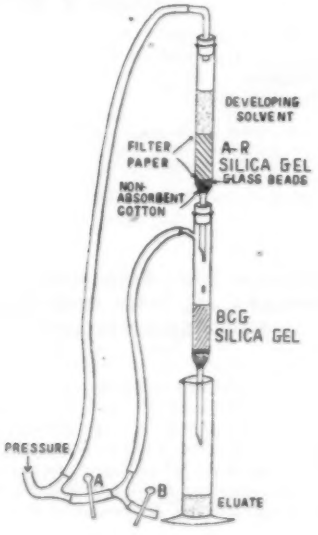
The silica was obtained by acidifying commercial sodium silicate solution to *p*H 8·5 (thymol blue) at 22° C. After suitable ageing[4], the precipitate was washed and dried at 110° C. for forty-eight hours, then sized (sieve aperture, 0·589 mm.) and dried for a further forty-eight hours. This silica had a large water capacity (Table 1). Six different batches of silicate solution obtained from two manufacturers yielded virtually identical products.

Table 1. Preparation of Columns
(2 gm. silica)

Column	Indicator (0·2%) (ml.)	NaOH (0·1 *N*) (ml.)	Water (ml.)
Alphamine red *R*	1·0	0·8	1·0
Bromocresol green	0·5	2·1	0·2

Two columns were prepared after thorough mixing of the silica with the solutions shown in Table 1. It will be noted that the two mixtures, one containing *R*—NH_4 indicator[5] (alphamine red *R* (Herstein), Amend Drug and Chemical Corp., New York) and the other bromocresol green, differed considerably in the amount of alkali present, with a resulting difference in the R_F value or threshold volume for any given acid. The prepared silicas were slurried in chloroform-butanol (199 : 1) and packed into glass tubes (14 mm. internal diameter) according to the technique described by Neish[6]. The two columns were then joined as shown in the accompanying diagram. Flow of solvent through the lower column was regulated by alternate opening of the pinchcocks *A* and *B*, so that the solvent present on the surface of this column never exceeded a few drops.

In a complete analysis the following procedure was used. The solution of acids in 2 ml. of chloroform-butanol (99 : 1) (v/v) was washed into the alphamine red *R* column in the conventional manner. During subsequent development with chloroform-butanol (199 : 1), octanoic and hexanoic acids passed rapidly through this column into the bromocresol green column. Here they were fractionated, and the portion containing octanoic acid was collected and titrated.



The hexanoic acid band was now visible provided that this acid was present in amounts equivalent to 0·3 ml. of 0·01 *N* alkali. Development was continued until the bu yric acid band was on the point of leaving the alphamine red *R* column. At this time the columns were separated, and independent elution was completed with appropriate solvents.

Table 2. Complete Analysis with Double Column

Column	Acid	Threshold (ml.)	Chloro-form-butanol*	Volume collected (ml.)	Titration (ml. of 0·01 *N* NaOH)	Recovery (%)
Bromo-cresol green	C_6	—	199 : 1	12	0·82	98
	C_6	13	99 : 1	16	1·10	103
	C_5	29	99 : 1	50	1·03	100
Columns split at 17 ml.	C_4	18	99 : 1	20	0·91	99
Alphamine red *R*	C_5	40	9 : 1	28	1·31	100
	C_7	70	9 : 1	100	1·44	101

* Equilibrated with one-tenth volume of water.

The results obtained from a typical fractionation are given in Table 2. Octanoic and heptanoic acids are not separated, and the separation of heptanoic from hexanoic acid is incomplete (80 per cent). Each column may be used several times.

Further details, together with a description of the distillation method and the extraction of acids into chloroform-butanol, will be published elsewhere.

We are indebted to the National Research Council of Canada, and to Swift and Co., for financial assistance.

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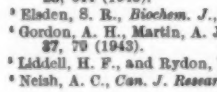
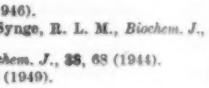
Tropolone

The existence of a new type of aromatic ring system, tropolone (I), was first postulated[1] to account for the chemistry of stipitatic acid, and the occurrence of this ring system in a variety of natural products has now been established[2]. Various derivatives of tropolone have been synthesized[3], and recently three independent syntheses of tropolone have been described[4]. Since it is evident that its chemistry will soon be investigated in detail, it seems of interest to see whether its behaviour can be predicted theoretically before such experimental evidence is at hand.



I



II

Calculations of energy-levels in the symmetrical anion (II) derived from the acid (I) have therefore been effected, using the standard molecular orbital method. This method is not always very successful with heteroatomic systems such as (I) in which mesomerism involves charge separation; but sym-

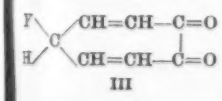
metrical cyanine-like ions such as (II) seem more favourable[5]. The additional parameters involved were given values which seem appropriate to such ions; the coulomb term of oxygen relative to carbon was set equal to β, and the C—O resonance integral to $\beta\sqrt{2}$, where β is the usual C—C resonance integral. The coulomb terms of carbon atoms separated by n bonds from oxygen were given the value $(0{\cdot}4)^n\beta$, following Branch and Calvin[6] and McGowan[7] (cf. Dewar[8]). The effects of the two oxygen atoms were taken to be additive.

Resonance-energy. The calculated resonance-energy of (II) is 3·15 β, or 57 kcal.; that of (I) will presumably be about 10 kcal. less. Tropolone should therefore have a resonance-energy comparable with that of benzene and probably somewhat greater. This calculation supports the earlier qualitative arguments that the ring system (I) should show aromatic properties.

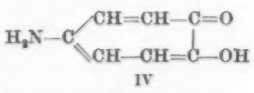
Light absorption. The calculated excitation energies for the first four transitions are 0·99, 1·00, 1·66 and 1·67 β; and the value of β_{spec} for related ions[6] is 73·2 kcal. Tropolone should therefore show double maxima in alkaline solution at about 390 and 235 mμ. Tropolone itself, by analogy with other similar compounds, should show similar absorption, but with the 390 mμ band weakened and shifted slightly to higher frequencies. According to Cook *et al.*[4], the observed spectrum of (I) in alcohol showed maxima at λ = 352, 320, 237 and 228 mμ; while Doering and Knox[4] found maxima at λ = 392, 368, 327 and 235 mμ (solvent not stated). The agreement with theory is unexpectedly good: and the extra band found by Doering and Knox at 392 mμ may well correspond to the ion (II), particularly if their solvent was water. The absorption spectra of puberulic and stipitatic acids (Todd *et al.*[2]) are similar.

Type of transition state		$\Delta E/\beta$ Electrophilic	Radical	Nucleophilic
Tropolone	*ortho*	2·564	2·466	2·368
	meta	2·686	2·406	2·126
	para	2·086	2·302	2·554
Phenol	*para*	2·178		

Orientation of substitution. When proper allowance is made for the change in electron affinity of carbon atoms due to the inductive effect, it is no longer legitimate to relate rates of substitution to charge distribution; and the most reliable procedure[8] seems to be to calculate the relative π-electron energies of the various possible quinonoid transition states, for example, (III). Such values are given in the accompanying table, the quantities ΔE being differences in total π-electron energy between the transition states and (II). A value for electrophilic *para* substitution in phenol is also given. (The positions in (II) are termed *ortho*, *meta* and *para* by analogy with phenol.)



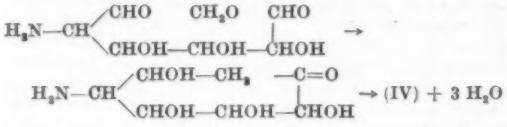
III



IV

These results suggest that electrophilic substitution in tropolone should take place almost exclusively *para*, radical substitution mainly *para*, and nucleophilic substitution—if it can be observed—*meta*. Electrophilic substitution should occur with about the same ease as in phenol. The orientation of substitution in tropolone is not yet known, but it does couple with *p*-toluene-diazonium salts (Cook *et al.*[4]). Reduction of such azo compounds should give *p*-aminotropolone (IV), a compound which may show interesting pharmacological properties since it is the tropolone analogue, and an isomer, of *p*-aminobenzoic acid.

In this connexion it is conceivable that (IV) may be a precursor of *p*-aminobenzoic acid, the conversion of tropolones to benzenecarboxylic acids being one of their characteristic reactions; and that the biogenesis of other benzene derivatives may take place through intermediate tropolones. Various biogenetic schemes for tropolone can be suggested, of which the most attractive seems to be oxidation of a hexose to a dialdehyde, followed by condensation with formaldehyde and dehydration; and such a reaction with glucosamine would give (IV):



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[1] Dewar, *Nature*, **155**, 50 (1945). For convenience, classical structures have been used throughout this note.
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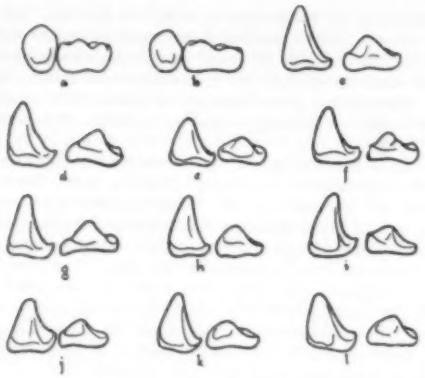
South African Fossil Hominoids

In a letter published in *Nature*[1], Prof. S. Zuckerman stated categorically that the lower milk canines of the fossil Australopithecinæ found at Taungs and Kromdraai (*Australopithecus* and *Paranthropus*) do not differ "in shape and dimensions, relative and absolute", from that of the chimpanzee. It appears, however, that this statement was based only on the three overall dimensions of height, length and breadth in a series of fifteen specimens[2]. We have now repeated our previous comparative studies on fifty immature chimpanzee skulls and have confirmed that the milk canine in this series presents a morphological pattern very different from that of the South African fossils.

In the accompanying figure are shown scale drawings (natural size) of the medial aspect of the milk canine and first milk molars of (*a*) *Homo sapiens*, (*b*) the australopithecine specimen from Kromdraai, and (*c–l*) those of ten young chimpanzees taken at random from the series of fifty, excluding six which were classified as grossly distorted by advanced wear, but including those "slightly" or "moderately" worn. The Kromdraai milk canine is practically unworn,



and that of the Taungs skull belongs to our category of "moderate wear". The drawings make clear a few of the morphological features in which the chimpanzee canine differs from the Kromdraai specimen, and similarly from that of *Homo*. These features (which are uniformly present in all the canines of our series) include a conical and sharply pointed crown projecting well above the level of the molars, a concave posterior border extending down to the cingulum, and an approximately straight and horizontal internal cingulum which extends back to form a heel (or talonid) projecting beyond the level of the rest of the crown. The maximum width of the canine in all cases also exceeds that of the first milk molar. By contrast, the Kromdraai and modern human canines are spatulate with a flattened medial surface, relatively short and bluntly pointed, their posterior borders above the level of the cingulum make contact behind with the first milk molar, and their transverse width is small relatively to that of the latter. It may further be noted that in the Kromdraai specimen (as is commonly the case in modern man) the anterior border of the canine makes direct contact with the lateral incisor; in none of the chimpanzee series is this the case. Incidentally, the illustration also makes clear the marked contrast in shape and structure between the first milk molars of the chimpanzee and those of *Paranthropus* and *Homo*.

The overall dimensions of height, length and width by themselves can scarcely permit a comprehensive statement that the shape of one tooth does not differ from another. This, of course, applies to the permanent as well as the deciduous teeth. However, if measurements are carefully selected for their relevancy in testing the obvious differences in shape observed on direct visual comparison, these differences can, if necessary, be expressed metrically. The following percentage ratios are here recorded as examples: in the list *C* refers to the ranges of variation in our chimpanzee series (with means and standard deviations in brackets), *K* to the australopithecine milk dentition found at Kromdraai, and *T* to the Taungs skull: max. a.p. length of upper half of canine/total height of canine: *C*, 42–62 (52·0, 5·5); *K*, 78; *T*, 100; max. width of upper half/max. a.p. length of upper half: *C*, 82–111 (98·6, 8·2); *K*, 71; *T*, 65; max. a.p. length of upper half of canine/max. a.p. length at level of basal cingulum: *C*, 56–72 (63·3, 4·3); *K*, 116; *T*, 126; max. height of canine/max. height of first milk molar: *C*, 155–215 (180·7, 14·0); *K*, 130; *T*, 129; max. height of canine/max. height of second milk molar: *C*, 185–268 (219·2, 21·4); *K*, 108; in the Taungs skull the second milk molar is too severely worn down by attrition to obtain this index.

The details of these and other metrical data will be published *in extenso* elsewhere (together with data on the permanent dentition which demonstrate similar contrasts between the Australopithecinæ and the anthropoid apes). They could, of course, be multiplied if this were really considered necessary; but by themselves they appear to show conclusively that the australopithecine milk canine is certainly much more hominid in its shape and proportions than any chimpanzee in our series of fifty skulls. If, however, a chimpanzee milk canine is known in some other series, which presents a total morphological pattern made up of a combination of hominid features comparable to that of the Kromdraai tooth, may we be informed where this unique specimen is to be seen? In this connexion, it is to be noted that at least four excellent specimens of the deciduous dentition of the Australopithecinæ are now known, and in all of them the milk canines present general hominid characters (though, of course, showing certain differences in detail).

I am indebted to Dr. L. H. Wells, of the Witwatersrand University, and Mr. J. T. Robinson, of the Transvaal Museum, for checking measurements on the original specimens from Taungs and Kromdraai. I am also grateful to Mr. D. J. Finney, lecturer in the design and analysis of scientific experiment at the University of Oxford, for his advice in the analysis of the statistical data.

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Emanating Power and the Age of Complex Silica Gels

Parchomenko[1] demonstrated that, when mixing silica gels with electrolytes of some metals such as magnesium, manganese, cobalt and nickel (with iron always present) by precipitating their chlorides with sodium silicate, compounds can be prepared which are highly absorbent for radioactive salts, and owing to their large colloidal surface give off radon nearly quantitatively.

One of us[2] examined the emanating power of these complex silica gels under different conditions of dryness and age up to 45 months and found that drying for 3–5 hr. at 120° C. or by laboratory air with the relative humidity 20–40 per cent had little effect. On the other hand, the emanating power decreased considerably when the gel was oversaturated with water, but was regenerated after drying. Some results of these experiments together with recent measurements are summarized in the accompanying table, where the emanating power is given by the relation of radon escaping from the sample to the whole amount of radon developed by it. The note "dry" means samples held only at the normal laboratory temperature; "very dry" means samples heated at 120° C. for several hours. The samples are of yellow-brown colour due to colloidal ferric hydroxide. Nos. 1 and 3 are powders with grains less than 0·1 mm. in diameter; No. 2 is granulated with particles of size 1–2 mm.

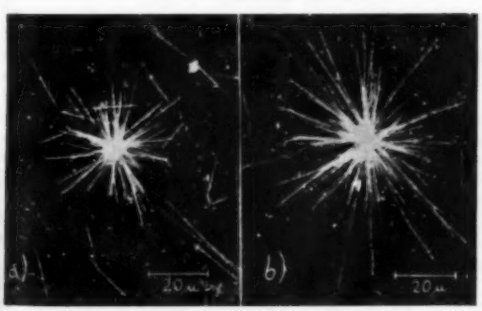
EMANATING POWER OF COMPLEX SILICA GELS

No. and composition of the sample	Date of preparation	Date of measurement	Emanating power	Note
1. 45·8 μgm. radium (iron + magnesium)-cations	Dec. 1, 1934	Dec. 4, 1934	97·0 per cent	Dry
		Jan. 22, 1936	97·0	,,
		Oct. 4, 1938	92·8	,,
		Jan. 18, 1950	89·0	,,
2. 47·3 μgm. radium (iron + magnesium)-cations	Mar. 1, 1934	Mar. 30, 1934	97·6	Dry
		Mar. 31, 1934	40·0	Moistened with water
		Jan. 22, 1936	81·0	Dry
		Nov. 30, 1937	77·6	Very dry
		Jan. 18, 1950	65·0	Dry
3. 61·0 μgm. radium (iron + manganese)-cations	Oct. 10, 1934	Oct. 30, 1934	98·0	Dry
		Jan. 22, 1936	92·6	,,
		Dec. 1, 1937	90·9	Very dry
		Dec. 20, 1949	66·0	Dry

It can be seen from the table that the silica gels lost during the past sixteen years less than half their emanating power in the case of samples 2 and 3, and a few per cent only during twelve years in the case of sample 1. The emanating power is intimately connected with the great inner surface of gels, which in turn depends on the presence of adsorbed water in the inner capillaries of the gel. Gels which have lost their internal water crystallize, and their emanating power falls to less than 1 per cent as shown by Hahn[3] for ferric oxide gels. From these facts it follows that crystallization progressed very little if at all in sample 1 and markedly in samples 2 and 3, this difference being obviously due to different relations of their contents of electrolytes to the amount of silica gel.

Kyropoulos[4] found by X-ray spectroscopy no change in the amorphous structure of pure silica gels five years old, and Sedlitzkij[5] proved that mixed mineral gels resembling montmorillonites in structure, that is, containing magnesium ion and ions of alkaline earths, give, after only four years at laboratory temperature, characteristic X-ray interferences due to partial crystallization. Our results are in complete accord with these two results, since our complex silica gels can behave either as pure silica gels when their content of electrolytes is insignificant, as in sample 1, or as montmorillonites, which they resemble in structure, if their content of electrolytes is noteworthy (samples 2 and 3).

We have tried to examine the emanating power of the finest particles of silica gel by the photographic method, using Ilford Nuclear Plates *C* 2 with the emulsion 100 μ thick. A small portion, about 1 c.mm. of sample 1, was carefully pulverized and dispersed in 2–3 c.c. of water. After 5 min., which was necessary to allow coarse particles to settle, some drops of the liquid with an invisible suspension of the finest grains were put on the emulsion and left there until completely evaporated. The emulsion first swells up but becomes again smooth after desiccating, and the grains of silica gel are fairly well fixed in it, forming perfect centres for the alpha-ray stars. The plates are developed after one or two days. One of the results is reproduced in Fig. *a*. Even the finest particles with diameter as small as 2 μ emit alpha-rays of radium only, showing that the emanating power is maintained even for these small dimensions.



Alpha-ray stars from a grain of (*a*) radium–silica gel, and (*b*) radium–barium sulphate

For comparison, the experiment was repeated with radium–barium sulphate and with the same concentration of radium as in the previous case. This time (Fig. *b*) the star contains also long tracks of alpha-rays from radium C′, though the exposure was the same (two days) as for silica gel. With longer exposures even the grains of silica gel will give tracks of alpha-rays from radium C′ because only half of the radon developed escapes into the air and the other half is absorbed by the gelatine of the plate.

At least the order of concentration of radium in grains which are centres of the stars can be determined. Microscopic examination of the plate gives a mean value of 148 alpha-rays from radium per day for a total volume of the grains equal to 413 μ^3 and for grains of size ranging from 2 to 6 μ. If we use for the transmutation-rate of radium the value of $3{\cdot}72 \times 10^{10}$ alpha-rays/sec., and for the density of silica gel particles 1·5 gm./c.c., then $1{\cdot}9 \times 10^{-12}$ gm. of silica gel will contain $3{\cdot}1 \times 10^{-16}$ gm. of radium and will emit one alpha-particle per day. Thus the mass relation, radium to silica gel, equals 1/6,000 ~ $1{\cdot}6 \times 10^{-4}$, in excellent agreement with the number deduced from the weight of the whole amount of sample 1 (0·277 gm.) and its radium content (0·0458 mgm.), namely, $1{\cdot}6 \times 10^{-4}$; that the two figures are exactly the same is, of course, pure chance.

Biltz[6] gives for the primary capillaries of silica gels with diameter of molecular dimensions, which are not destroyed by pulverizing, the maximal length of 45 μ, whereas Treadwell and König[7] give 0·26–0·44 μ only. Our photographic check seems to confirm the lower value.

It is obvious that the emanation method used by us can be employed for the examination of the ageing process of silica gels. In doing so, care must be taken to take sufficiently low concentrations of radium in order to prevent any considerable effect of the decomposition of internal water by alpha-rays which could disguise the true result. This effect was of very small order in our experiments. Taking Bemmelen's figure[8] of six molecules of water for every molecule of silica in fine pulverized gels, we estimate the amount of internal water in sample 1 to be about 100 mgm. Thus, when 50 c.c. of the explosive gas from the water produced in one day by the action of alpha-rays from 1 gm. of radium and supposing that all alpha-rays of the radium contained in the silica gel are absorbed in the internal water only—which, of course, is not the case—we find that, at most, 0·70 mgm., that is, 0·70 per cent of the internal water of

sample 1, has been decomposed by the alpha-radiation during the 15 years and 2 months of its existence.

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X-Ray and Neutron Diffraction by Graphite Layers

Franklin[1] has shown that an anomalous two-fold increase of the X-ray diffraction intensity is observed for the two-dimensional 10 carbon band. She explains this by the fact that the *L*-electrons are not distributed spherically about the carbon nucleus but are concentrated about the centres of the C—C bonds. I have obtained further evidence in support of this explanation from X-ray and neutron diffraction measurements.

X-ray powder photographs of a sample of artificial graphite show an enhancement of about 85 per cent for the $10\bar{1}0$ line relative to $11\bar{2}0$, and about 80 per cent for the $10\bar{1}1$ line relative to $11\bar{2}2$. Franklin's assertion that this enhancement is not due to a temperature factor, as inferred by Lipson and Stokes[2], is confirmed by quantitative comparison of intensities on photographs at 20° and 500° C. These show that the components of thermal vibration are a maximum along the *c*-axis and fall off as cos α to a negligible value in the plane of the carbon layers, where α is the angle between the *c*-axis and the normal to any *hkil* plane. The magnitude of the intensity changes found corresponds to a Debye temperature of about 530° K. for vibrations along the *c*-axis. From these temperature effects even the $11\bar{2}2$ line, of those mentioned above, would be affected by less than 5 per cent.

In the case of neutron diffraction, the scattering centres are the nuclei, and not the electrons, so that if Franklin's explanation is correct the neutron intensities should show no anomalies. With the experimental arrangements for powder diffraction employed hitherto, the pairs of lines $10\bar{1}0$, $10\bar{1}1$ and $11\bar{2}0$, $11\bar{2}2$ are imperfectly resolved, so comparison has been restricted to the ratios of theoretical and measured intensities of the two pairs. These are in agreement to an accuracy of 5 per cent, showing that the anomalous X-ray results appear to be almost entirely due to the asymmetric electron distribution.

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Atomic Energy Research Establishment,
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July 10.

[1] Franklin, R. E., *Nature*, **165**, 71 (1950).
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A Scintillation Spectrometer for High-Energy Gamma-Rays

It has been shown[1,2] that energy measurements with scintillation counters can be made with considerable accuracy with the aid of the 'photo-electron lines' in the pulse–height distribution. But the application of this method to energies exceeding 2 MeV. is attended by difficulties. In this energy-range it is better to measure the energy of the electron-positron pairs produced by the gamma-rays. The following procedure was adopted for this purpose. Collimated gamma-rays are allowed to impinge upon the sodium iodide crystal of a scintillation counter (Fig. 1). The crystal is flanked by two other scintillation counters placed opposite one another.

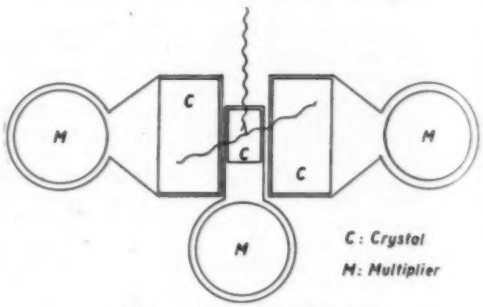

Fig. 1. Diagram of the apparatus

The purpose of these counters is to record the two annihilation quanta emitted from each electron-positron pair produced in the central crystal. Coincidences between these two counters are used to separate pair-production pulses from other pulses of the central counter. Only the former are counted. The pulse–height distribution is studied with the aid of a discriminator. The apparatus was calibrated by measurements made with the central counter only, in the manner described earlier[1].

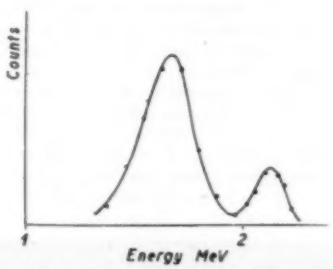

Fig. 2. Pulse–height distribution for gamma-rays from antimony-124

Fig. 2 shows the pulse–height distribution for the gamma-rays from antimony-124. The energy of the rays (energy of electron-positron pairs plus 1·02 MeV.) is recorded along the abscissa. The peaks correspond to the two energies 1·7 and 2·1 MeV. The present apparatus is capable of measuring down to about 1·5 MeV. The advantage of this method is that every gamma-ray energy gives only one peak in the pulse–height distribution curve.

Recently, pair-production peaks have been observed by Pringle, Roulston and Standil[3] and by Hofstadter and McIntyre[4]. In those measurements,

however, the pair-production peaks and the Compton distributions are not separated but appear simultaneously in the pulse – height distribution.

SVEN A. E. JOHANSSON

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July 3.

[1] Johansson, S. A. E., *Nature*, **165**, 396 (1950). *Arkiv för Fysik*, **2**, No. 18 (1950).
[2] McIntyre, J. A., and Hofstadter, R., *Phys. Rev.*, **78**, 617 (1950).
[3] Pringle, R. W., Roulston, K. J., and Standil, S., *Phys. Rev.*, **78**, 627 (1950).
[4] Hofstadter, R., and McIntyre, J. A., *Bull. Amer. Phys. Soc.*, **25**, 16 (1950).

Haploid Plants of *Solanum demissum*

THE wild hexaploid ($2n = 72$) species *Solanum demissum* Lindl. has been widely used in breeding for blight (*Phytophthora infestans*) resistance in potatoes. Crossed with cultivated *S. tuberosum* varieties (tetraploids with a chromosome number of $2n = 48$) it gives pentaploid ($2n = 60$) hybrids which can be back-crossed by *S. tuberosum*. An alternative method of breeding has been suggested by Black[1]. This consists of crossing *S. demissum* with a diploid ($2n = 24$) species such as *S. Rybinii* to get a tetraploid ($2n = 48$) F_1 hybrid, which is then crossed with *S. tuberosum* varieties. This latter method appears to have much to recommend it, particularly as Thomas[2] states that, in the hybrid *S. demissum* × *S. Rybinii* and in the triple hybrid (*S. demissum* × *S. Rybinii*) × *S. tuberosum*, "chromosome differentiation between these related species is not sufficient to affect pairing to any extent". This presumably means that, at least in the triple hybrid, about twenty-four bivalents are formed at meiosis.

As part of the potato-breeding programme at the Cambridge Plant Breeding Institute, crosses were made between *S. demissum* and diploids such as *S. Rybinii*, and between *S. demissum* and *S. tuberosum*, in order to compare the two methods of breeding. As is shown in the accompanying table, in addition to the normal tetraploid ($2n = 48$) F_1 hybrids, there were obtained plants with chromosome numbers of 60 and 36 from the cross *S. demissum* × diploid. The plants with 60 chromosomes are due to the functioning of diploid (24 chromosome) *S. Rybinii* gametes. The plants with 36 chromosomes are haploid *S. demissum*. They were typically small plants and had smaller and narrower leaflets than normal *S. demissum*. They also remained in the rosette stage much longer than the true F_1 hybrids, and the one plant which has flowered had much smaller flowers than found in normal *S. demissum*. Another haploid *S. demissum* was obtained in the cross of this species with *S. toralapanum* ($2n = 24$).

Meiosis has been examined in one of the *S. demissum* haploids. It is, of course, what Darlington[3] would call a polyhaploid, having three sets of 12 chromosomes each, and it is not, therefore, surprising that a preliminary examination of 19 cells at first metaphase showed on an average a frequency of 4·74 bivalents per cell. The detailed observations were one cell with 2 bivalents, six cells with 3, three cells with 4, two cells with 5, four cells with 6 and three cells with 8 bivalents.

Cross	No. of plants with a chromosome number of 36	48	60
S. demissum × *S. Rybinii* (H.W.H.)	2	10	1
S. demissum × *S. Rybinii* (G.S.B.)	—	4	3
S. demissum × *S. toralapanum* (G.S.B.)	1	2	—
S. demissum × *S. tuberosum* (H.W.H.)	—	—	14

Distant hybridization is a recognized way of obtaining haploids, and it is therefore of interest to note that Dr. K. S. Dodds (see the following communication) has also obtained haploid *S. demissum* plants from hybridizations similar to those reported above.

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Plant Breeding Institute,
School of Agriculture,
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June 21.

[1] Black, W., *Proc. Roy. Soc. Edinb.*, B, **63**, 290 (1949).
[2] Thomas, P. T., Thirty-sixth Annual Report, John Innes Horticultural Institution, 11 (1945).
[3] Darlington, C. D., "Recent Advances in Cytology" (2nd edit., J. and A. Churchill, Ltd., London, 1937).

Polyhaploids of *Solanum demissum*

Solanum demissum Lindl. ($2n = 72$) has been used at the Commonwealth Potato Collection as the maternal parent in various crosses with cultivated and wild diploid species ($2n = 24$) of *Solanum*. The results to date are given in the accompanying table.

Male parent	Number of hybrids	Chromosome numbers
Cultivated species		
S. stenotomum Juz. et Buk.	2	48 (1); 36 (1)
S. goniocalyx Juz. et Buk.	1	48 (1)
S. Phureja Juz. et Buk.	1	48 (1)
S. Ascasabii Hawkes	2	48 (1); 39 (1)
S. Rybinii Juz. et Buk.	9	48 (7); 60 (2)
Wild species		
S. Garcia Juz. et Buk.	1	60 (1)
S. Paradii Juz. et Buk.	1	48 (1)
S. platypterum Hawkes	1	48 (1)
S. Ballsii Hawkes	1	48 (1)
S. Soukupii Hawkes	1	48 (1)
S. toralapanum Cárdenas et Hawkes	6	48 (6)

The three pentaploids that occur probably arose by the functioning of unreduced gametes from the male parents.

Two plants are parthenogenetic polyhaploids of *S. demissum*, one with $2n = 36$ and the other with $2n = 39$. They are quite vigorous but are less robust than their maternal parents, and the leaves and flowers are reduced in size. Dr. Margaret A. Keay finds that each polyhaploid behaves to *Phytophthora infestans* as does the particular line of *S. demissum* from which it originated; the balanced one is a complete resister, and the unbalanced one an *AC* resister.

The unbalanced polyhaploid does not form more bivalents at meiosis than the balanced one, despite the fact that it must be disomic for the three extra chromosomes; the former showed a range of 1–8 bivalents (mean bivalents per nucleus = 4·7; 14 cells) and the latter, one of 3–8 bivalents (mean bivalents per nucleus = 5·6; 9 cells). Thus both hybrids give evidence of some intra-haploid homology of their chromosomes.

KENNETH S. DODDS

Commonwealth Potato Collection,
Huntingdon Road,
Cambridge.
June 28.

FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, November 6

SOCIETY OF CHEMICAL INDUSTRY, AGRICULTURE GROUP (joint meeting with the FOOD GROUP and the LONDON SECTION, at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 6.30 p.m.—Mr. R. Barrington Brock: "Scientific Aspects of Wine Production".*

Tuesday, November 7

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 5.15 p.m.—Dr. F. A. Bannister: "Crystallography in Modern Science, (ii) Crystallography in Geology".

DIRECTION GÉNÉRALE DES RELATIONS CULTURELLES OF THE MINISTÈRE DES AFFAIRES ÉTRANGÈRES AND THE CULTURAL RELATIONS DEPARTMENT OF THE FRENCH EMBASSY IN LONDON (in the Electrical Engineering Department, City and Guilds College, Exhibition Road, London, S.W.7), at 5 p.m.—Monsieur R. Giguet: "The Development of Electric Power Supply in France since the End of the War".* (To be repeated on Thursday, November 9, at 7.30 p.m. at Marischal College, Aberdeen, and on Monday, November 13, at 7.30 p.m. in the Engineering Department, The University, Glasgow.*)

INSTITUTION OF CIVIL ENGINEERS (at Great George Street, London, S.W.1), at 5.30 p.m.—Dr. W. H. Glanville: Presidential Address.

SOCIETY OF CHEMICAL INDUSTRY, CROP PROTECTION PANEL of the AGRICULTURE GROUP (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Dr. G. S. Hartley: "Physico-Chemical Problems in the use of Insecticides".*

UNIVERSITY OF LONDON (in the Department of Civil and Mechanical Engineering, King's College, Strand, London, W.C.2), at 5.30 p.m.—Prof. S. J. Davies: "Combustion in Compression-ignition Oil Engines".* (Further Lectures on November 14, 21 and 28.)

INSTITUTION OF ELECTRICAL ENGINEERS, EDUCATION DISCUSSION CIRCLE (joint meeting with the EDUCATION GROUP of the INSTITUTE OF PHYSICS, at Savoy Place, Victoria Embankment, London, W.C.2), at 6 p.m.—Discussion on "Teaching Physics to Engineers".

ROYAL AERONAUTICAL SOCIETY (at the College of Technology, Belfast), at 6.30 p.m.—Major P. L. Teed: "Aircraft Metallic Materials under Low Temperature Conditions".

SOCIETY OF DYERS AND COLOURISTS, MANCHESTER JUNIOR BRANCH (in the Reynolds Hall, College of Technology, Manchester), at 6.30 p.m.—Mr. H. B. Bradley: "The Development of a New Dyestuff".

ROYAL INSTITUTE OF CHEMISTRY, MANCHESTER AND DISTRICT SECTION (at the Municipal Technical College, Bolton), at 7 p.m.—Dr. E. Isaacs: "Industrial Developments in the Polymer Field over the last Twenty Years".

Wednesday, November 8

GEOLOGICAL SOCIETY OF LONDON (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Scientific Papers.

INSTITUTION OF ELECTRICAL ENGINEERS, RADIO SECTION (at Savoy Place, Victoria Embankment, London, W.C.2), at 5.30 p.m.—Mr. Caradoc Williams: "Low-Frequency Radio-Wave Propagation by the Ionosphere, with particular reference to Long-Distance Navigation".

PHYSICAL SOCIETY, LOW TEMPERATURE GROUP (joint meeting with SOCIETY OF INSTRUMENT TECHNOLOGY, in the Lecture Theatre, Science Museum, Exhibition Road, London, S.W.7), at 5.30 p.m.—Papers on "The Measurement of Low Temperatures".

BRITISH INSTITUTION OF RADIO ENGINEERS, NORTH-WESTERN SECTION (at Neville Hall, Westgate Road, Newcastle-upon-Tyne), at 6 p.m.—Mr. J. C. Martin: "Radio Navigational Aids".

MANCHESTER METALLURGICAL SOCIETY (joint meeting with the INSTITUTE OF METALS, at the Engineers' Club, Albert Square, Manchester), at 6.30 p.m.—Dr. B. R. Dudding: "Metallic Materials used in the Construction of Lamps and Valves".

SOCIETY OF CHEMICAL INDUSTRY, FOOD GROUP (at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 6.30 p.m.—Papers on "The Significance of Aqueous Vapour Pressure in the Food Industry".

INSTITUTE OF WELDING, MANCHESTER AND DISTRICT BRANCH (in the Reynolds Hall, College of Technology, Manchester), at 7 p.m.—Mr. E. F. Burford: "The Design of Pressure Vessels".

ROYAL INSTITUTE OF CHEMISTRY (at the County School, Ridgeway Road, Isleworth), at 7 p.m.—Dr. J. G. A. Griffiths: "Rockets and Chemistry".

SOCIETY OF VISITING SCIENTISTS (at 5 Old Burlington Street, London, W.1), at 7.30 p.m.—Discussion on "Physics and Archæology" (Speakers: Prof. F. E. Zeuner, Dr. J. McG. Bruckshaw and Mr. E. W. Jones).

Thursday, November 9

UNIVERSITY OF LONDON (at the Institute of Psychiatry, Maudsley Hospital, Denmark Hill, London, S.E.5), at 3 p.m.—Dr. H. McIlwain: "Metabolic Processes supporting the Activities of the Brain".*

ROYAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Sir Paul Fildes, F.R.S.: "The Development of Microbiology" (Leeuwenhoek Lecture).

ROYAL SOCIETY OF ARTS, DOMINIONS AND COLONIES SECTION (at John Adam Street, Adelphi, London, W.C.2), at 5.15 p.m.—Mr. E. W. Barltrop: "Labour Problems in the Colonial Empire".

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 5.15 p.m.—Dr. L. R. G. Treloar: "The Physics of Rubber-like Materials". (Further Lectures on November 16 and 23.)

PHYSICAL SOCIETY, COLOUR GROUP (at the Institute of Ophthalmology, Judd Street, London, W.C.1), at 5.30 p.m.—Mr. R. W. G. Hunt: "A Theory of Luminance Discrimination".

INSTITUTE OF METALS, LONDON SECTION (at the Royal School of Mines, Exhibition Road, London, S.W.7), at 7 p.m.—Prof. A. J. Murphy: "The Significance of some Less Common Metals".

Friday, November 10

ROYAL ASTRONOMICAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Scientific Papers.

CHEMICAL SOCIETY, EXETER SECTION (in the Washington Singer Laboratories, Prince of Wales Road, Exeter), at 5 p.m.—Dr. R. S. Cahn: "Editing for the Chemical Society".

CHEMICAL SOCIETY, NEWCASTLE AND DURHAM SECTION (in the Chemistry Building, King's College, Newcastle-upon-Tyne), at 5 p.m.—Dr. E. J. Bowen, F.R.S.: "Resonance Transfer of Energy between Molecules" (Bedson Club Lecture). (All Fellows are invited.)

UNIVERSITY OF LONDON (in the Physiology Theatre, University College, Gower Street, London, W.C.1), at 5.15 p.m.—Dr. W. S. Feldberg: "Chemical Transmitters".* (Further Lectures on November 21 and December 1).

UNIVERSITY OF SHEFFIELD (in the Firth Hall, Western Bank, Sheffield), at 5.30 p.m.—Rt. Hon. Lord Boyd-Orr, F.R.S.: "Political Problems raised by Modern Science" (Basil Hicks Lecture).

SOCIETY OF GLASS TECHNOLOGY, NORTH-WEST SECTION (at the Gas Showrooms, Radiant House, St. Helens), at 6 p.m.—Mr. S. W. Ratcliffe: "Glass in the Ceramic Industry".

INSTITUTE OF PHYSICS, INDUSTRIAL RADIOLOGY GROUP (at 47 Belgrave Square, London, S.W.1), at 6.30 p.m.—Messrs. G. Gradfield, L. T. Perriam, N. D. G. Mountford: "Ultrasonic Flaw Detection".

OIL AND COLOUR CHEMISTS' ASSOCIATION, MANCHESTER SECTION (at the Engineers' Club, Albert Square, Manchester), at 6.30 p.m.—Mr. F. I. G. Rawlins: "Scientific Methods of Examining Paintings".

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 9 p.m.—Prof. Gordon F. Hull, Jr.: "Microwave and Optical Analogues".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

ASSISTANT LECTURER IN THE SCHOOL OF PHARMACY, Plymouth and Devonport Technical College—The Director of Education, Cobourg Street, Plymouth (November 11).

CHEMIST AND BACTERIOLOGIST—The Engineer and Manager, Water Department, Town Hall, Reading, endorsed 'Chemist and Bacteriologist' (November 13).

ENGINEERING ASSISTANT (Historical Research) in the Department of Science and Industry—The Director, City Museum and Art Gallery, Birmingham 3 (November 20).

METALLURGISTS (Experimental Officer grade) for laboratory work in a Ministry of Supply establishment in North-West England—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting F.626/50A (November 20).

PHYSICISTS (Scientific Officer grade) in the Ministry of Supply (Atomic Energy Division) in London—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting A.285/50A (November 20).

METALLURGISTS at Ministry of Supply Research Establishments near London: PHYSICAL METALLURGISTS (Scientific Officer grade) (Ref. F.635/50A) with research experience in metallography and a first- or second-class honours degree in metallurgy; EXPERIMENTAL OFFICER or ASSISTANT EXPERIMENTAL OFFICER (Ref. F.636/50A) with an interest in research on refractories and trained in metallurgy to H.N.C. standard or equivalent—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting the appropriate Ref. No. (November 25).

SCIENTIFIC TECHNOLOGIST on the Coal Survey headquarters staff in London—The National Coal Board, Establishments (Personnel), Hobart House, Grosvenor Place, London, S.W.1, quoting TT/267 (November 25).

PROFESSOR OF PHYSICS at Gordon Memorial College, Khartoum, Sudan—The Secretary, Inter-University Council for Higher Education in the Colonies, 1 Gordon Square, London, W.C.1 (November 30).

ASSISTANT LECTURER AND DEMONSTRATOR IN THE CHEMISTRY DEPARTMENT—The Secretary, King's College of Household and Social Science, Campden Hill Road, London, W.8.

BIOCHEMIST, who will also undertake hydrography (chemistry of sea water), and a MARINE BIOLOGIST (preferably a planktologist), at the East African Marine Research Station, Zanzibar—The Under-Secretary of State, Colonial Office, Research Department, Sanctuary Buildings, Great Smith Street, London, S.W.1.

CEREAL SEED CROP INSPECTOR—The Secretary, National Institute of Agricultural Botany, Huntingdon Road, Cambridge.

GOVERNMENT ANALYST in Barbados—The Director of Recruitment (Colonial Service), Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting 27106/44/50.

HEAD OF A NEW DEPARTMENT OF MANAGEMENT STUDIES—The Registrar, Portsmouth Municipal College, Portsmouth.

JUNIOR RESEARCH OFFICER (male) for analytical work, including development and application of analytical methods—The Director, British Cotton Industry Research Association, Shirley Institute, Didsbury, Manchester 20.

SENIOR RESEARCH OFFICER for work in connexion with marine refrigeration and overseas transport of perishable goods—The Secretary, Refrigerated Cargo Research Council, Cunard House, 88 Leadenhall Street, London, E.C.3.

SUPERVISING ENGINEER in the Public Works Department, British Guiana—The Director of Recruitment (Colonial Service), Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting 27322/161.